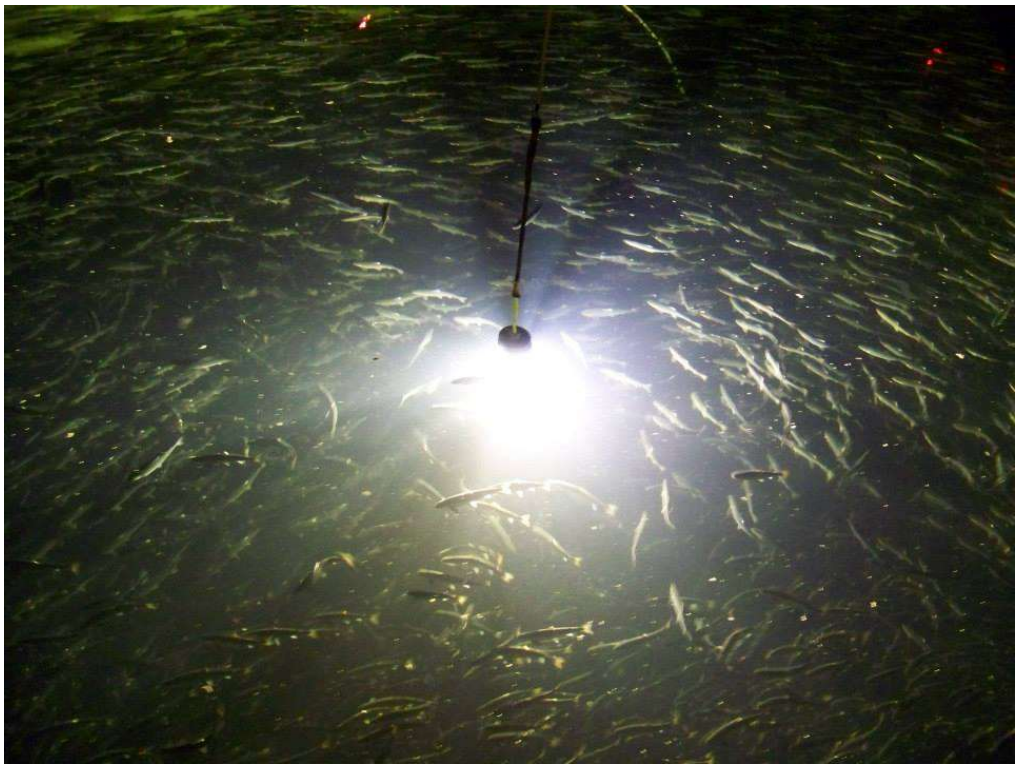
Feasibility Evaluation of Innovative Fish Farming Technologies to Prevent to Spread of COVID19 and Increase Productivity at Ontario Aquaculture Farms

Prepared for Ontario Aquaculture Association
February 2021



Prepared by Ron Hill, Aquaculture Consultant
Velocity Aqua- Aquaculture Solutions

Velocity Aqua

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Abstract

A feasibility study was undertaken to examine innovative technologies that could be adopted by the Ontario aquaculture sector with the dual purpose of reducing transmission of the COVID19 virus and improving efficiency in the sector long term. Members of the Ontario Aquaculture Association were contacted for their input and needs before technologies were researched and investigated for their merits. Ontario finds itself lacking the automation technologies found at comparable farms in North America and Europe, which is affecting the industry's ability to maximizing the prevention of COVID19 spread. Automation technologies were found to have the biggest potential to limit COVID19 spread while providing valuable increases to farming production as a co-benefit. Fish pumps would be of high value, but materials handling equipment, counters, graders, egg sorters and feed systems are all good recommendations to prevent the spread and increase production as are any technologies which eliminate the need for workers to perform shoulder-to-shoulder labour.

Purpose and Goals

Velocity Aqua was engaged by RJ Taylor on behalf of the Ontario Aquaculture Association (OAA) to research potential technologies that could be adopted by members of the OAA that would reduce the potential spread of the COVID19 virus while providing long term co-benefit to the sector. To that effect, Velocity Aqua engaged 14 prominent members of the OAA to get a representative sample of a) how farms were coping and adapting their operations during the pandemic; b) the current technology at their farm; c) potential technology upgrades and how they would prevent COVID19; and d) how those potential upgrades would increase their productivity long term. These interviews provided Velocity Aqua with a comprehensive list of potential technologies for investment in the Ontario aquaculture sector.

Using these interviews as a platform, the feasibility of each technology was explored to determine which were the most suitable to prevent the transmission of COVID19 as well as provide the greatest benefit for investment long term. Aquaculture and fish farms are diverse and so are the solutions needed by farms and businesses, thus, there is no one single technology recommendation that can be put forward. The categories of technological investment (materials handling equipment or centralized feeders) are designed to be broad enough for farms to work within to find appropriate equipment, technology or upgrades for their specific farm needs and shortcomings. The focus is on farming technologies that will limit the spread of COVID19 rather than PPE and protective equipment such as masks or plexiglass dividers that are only adopted to keep people safe.

Introduction

The COVID19 virus and its variants have had a severely detrimental effect to many industries across Canada costing millions of dollars and relentlessly damaging businesses and even causing some to go bankrupt. Terrestrial farms and processing facilities for beef and pork have been epicentres for several high-profile outbreaks in Canada and the United States. The aquaculture industry in Ontario, like other industries, has adapted its practices to protect workers during the pandemic. An outbreak on an aquaculture farm could be particularly devastating because of their small, specialized workforces and the expertise required to maintain the animals.

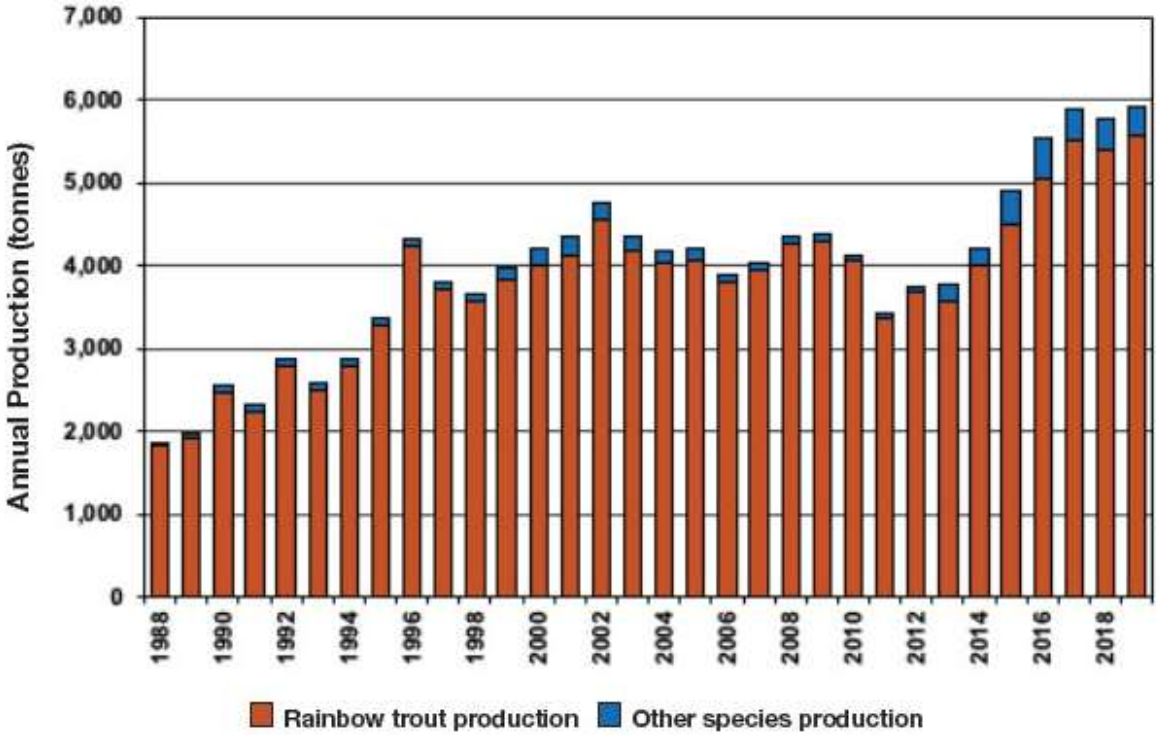
Unlike raising terrestrial animals, the aquaculture farmer must maintain the environment for their stock in much more comprehensive fashion. The water supply, temperature and oxygen levels are all critical for aquatic life. Terrestrial farmers must supply food and water and make sure their stock does not die of exposure, but they do not have to supplement a flow of oxygen or provide filtration, disinfection, and a non-stop flow of water. A break in care at a fish farm for even one day, such as if there was a COVID19 outbreak, could be devastating for the stock and the business.

The Ontario aquaculture sector has done its diligence and made sure to follow local health guidelines to enforce masks, physically distance staff and make changes to their processes to limit the virus' spread. Process changes can only go so far, too much work on the farm requires the staff to work together in tight proximity because the technology is not in place to reduce labour and change the scope of the staff's workload. The largest COVID19 risk on Ontario farms comes from the congregating of workers shoulder to shoulder to perform demanding tasks. This risk can largely be offset by adopting technology that currently exists today.

The Ontario Aquaculture Industry

The Ontario aquaculture industry is unique in Canada. The industry in Ontario is much larger than the other inland provinces, with the largest number of freshwater net-pens in Canada. Ontario is dwarfed by the coastal provinces with their ability to use the ocean for aquaculture. Locations are well situated close to major urban centres in Canada and the US allowing for nominal transportation cost. Aquaculture has been practiced in Ontario for over 60 years and contributes 126 million dollars annually to Ontario's economy (Moccia 2020) employing, directly and indirectly more that 550 people. Aquaculture is a growth industry in Ontario, increasing annual production by 135% from 2011-2017 (OAA 2018)

Figure 1- Ontario Aquaculture Production 1988-2018 (Moccia 2020)



South western Ontario and Manitoulin Island are Ontario's aquaculture hotspots, but other facilities are scattered throughout the province. Rainbow trout dominates the Ontario industry, most of the production coming from net-pen sites situated around Manitoulin Island. Fingerlings are largely supplied to the net-pens by facilities around southwestern Ontario. The province has some interesting niche farms: a large tilapia and barramundi facility near Mossley and two shrimp facilities located in Sudbury and one near Aylmer. There are many U-fish ponds, and small operators selling pond stocking fish or value-added products. The aquaculture industry in Canada has a major labour shortage, which

can be seen at Ontario farms. Many farms are looking to reduce labour by implementing technology and attracting more skilled labour.

Many farms are in rural communities, providing important local jobs where there are few. Interest and involvement of native peoples is very prevalent in Ontario as new First Nations aquaculture projects are developing every year. Currently 75% of rainbow trout grown in the province are grown through a long-term partnership with First Nations communities (OAA 2018), providing opportunities to remote First Nations communities.

The long-term outlook for the Ontario aquaculture sector is promising. Rainbow trout farming operations continue to be consolidated, with many modernization, optimization, and expansion efforts afoot. Proposed expansions, including partnerships with First Nations, to new waters will continue to increase production in the sector for rainbow trout and fingerling producers (Moccia 2020). Significant technological investment in net-pen farm operations can revolutionize operation and increase fish size, efficiency, and profitability.

Land based operators have been hit much harder by the pandemic and many have needed to shift their business model and had major issues receiving supplies. Despite the short-term setback of the pandemic, land-based producers in Ontario should see continued success. Fingerling demand should continue to rise as net-pen operations expand and become more efficient. Small to medium scale land-based aquaculture farms will continue to develop for niche species and current farms for warm water species should continue to develop their production once the pandemic subsides (Moccia 2020).

The State of Aquaculture Technology in Ontario

Unlike many of the companies that dominate the coast, Ontario's aquaculture farms are locally owned, not owned by multinationals. As a result, Ontario's farms, like many smaller farms everywhere, suffer problems of scale that discourage investments in technology. Aquaculture technology is aimed at the largest, most profitable sectors of aquaculture- the ocean farms that produce Atlantic salmon. As a result, many aquaculture technologies are extremely expensive and designed to be built on a scale surpassing the needs of Ontario farmers. The increase in scale is achieved by using the huge coastline of the ocean and farming a species that grows large- Atlantic salmon.

A perfect example of the difference in scale between ocean farmers and Ontario farmers can be seen in the specialized harvest boats and well boats employed by Atlantic salmon farmers. Greig Seafood unveiled the "Ronja Islander" in February 2020 (Greig Seafood 2020) which is the most technologically advanced aquaculture work boat in Canada. It was designed to operated in British Columbia and was custom built in Norway for $40 million CAD. The companies that produce Atlantic salmon in Canada are large, multinationals who own farms and produce a much larger growing fish on a farming scale far above the Ontario sector. They will implement technological solutions on a broad scale across dozens of farms with vast amounts of capital to invest. A piece of technology like the "Ronja Island" will service all Greig Seafood's needs on the BC coast, which includes 22 farms producing 23,400 tons of salmon per year – Ontario's total production of all seafood in 2019 was 5,923 tons (Moccia 2020). Greig seafood is only the third largest Atlantic salmon producer on the west coast. Technology companies aim sales at these huge companies, not sparing much thought for sales to smaller scale operators because the large company contracts are much more lucrative. These industry dominating companies can afford the immense capital outlay and implement on a much larger scale than the small Ontario farmer.

Figure 2-Greig Seafood's Ronja Island (Greig Seafood 2020)

The smaller scale of Ontario farms and the diverse nature of the farms and ownership means that investing in technology is a much bigger task and much bigger risk for Ontario aquaculture operations. Most Ontario farms, large and small, have been slow to adopt new technology and automation. While farms may have some modern equipment, many have limited technology upgrades or shortcomings in certain areas. In general, compared with coastal salmon farms or European (especially UK) trout farms, Ontario's aquaculture technology is years behind in automation technology like fish pumps, materials handling, harvesters, graders, and counters. While it is unrealistic to expect Ontario farms to adopt all the technology of large-scale salmon farms, there is still shortcoming in technology that is well established in farms of all sizes.

Farms without technology, particularly automation, have a hard time attracting skilled workers who are not interested in performing a job that is predominantly labour based. Skilled workers need skilled labour to perform.

Operations in Other Canadian Jurisdictions During COVID19

Other aquaculture operations across Canada have done what most businesses have done to fight COVID19: mandatory masks and physical distancing, process changes to keep people separate and increased ventilation where possible. Dividing barriers, physical barriers, and traffic control are used make sure people are using controlled access points and disinfected. These sites across Canada are generally more secure against the spread of COVID19 because the technology needed to reduce the spread is already in place. The degree of automation used in other provinces has eliminated much of the shoulder-to-shoulder work that is commonplace at Ontario farms.

Most farms outside Ontario have not adopted new farming technology to combat the spread of COVID19 because the technology is already in place that allows for physical distancing and greater efficiency. Mowi Canada's Dalrympyl hatchery has just adopted automated vaccination equipment, though the equipment was already planned for before the pandemic. This piece of equipment is a good example of the automation used in other sectors that has already been adopted and is helping to stop the spread. Used in conjunction with a fish pump this piece of equipment drops the labour needed for vaccinating fish from 17 down to 5 persons. (Lance Page pers comm). Cermaq Canada, Mowi Canada and Cooke Aqua have all increased their fleet size to isolate the crews at their sites and avoid possible infection between shifts (pers comm Lance Page, Scott Stangret, Gatchel Griffin). Companies are focusing on process changes to keep people distanced, whereas in Ontario there is no ability to make process changes to many tasks because the technology and equipment to do so is not in place.

Technology Evaluations

Ontario's two main farm types — Net-Pen Sites and Land-Based — have quite different operational and infrastructure requirements. They have been separated in our technical assessment into those that could have the most realistic benefit at net-pen sites and those at land-based sites.

A. Net-pen Sites

Ninety-six percent of fish production in Ontario is net-pen rainbow trout from Lake Huron. Ontario's net-pen sites almost exclusively raise rainbow trout fingerlings to market size (around 2.2kg) in 12-18 months. The province's net-pen farms are diverse, falling into three general categories, land linked, offshore and island based. Land linked farms are attached to shore by ramp, with the net-pens situated along steep drop offs. Offshore farms have their net-pens floating just offshore, but not attached, and must be attended to via boat. Island based farms are attached to islands located some distance from the mainland that must be accessed by boat. Compared to net-pens in other regions, Ontario's net-pens are well behind in technology and just starting to embrace automation. There has been limited investment in technology for operating net-pens in the last 20 years, thus, much of the work is still done manually.

1. Fish pumps

a) **Background:**

Fish pumps are designed to transport fish through hoses to a destination, eliminating the need to capture, handle and carry fish with nets. Fish pumps are specially design so that fish pass through without touching moving parts and are not damaged by the pump. Fish pumps are the typical piece of equipment for moving fish of every size and can move fish over long horizontal distances.

Fish are crowded up with a seine net and sucked through an intake hose. The fish travel the length of the hose and are deposited at their destination without leaving the water and without being handled by humans. Because they are always in water and are not handled, stress levels and fish condition are far superior to handling with nets. Farmers use fish pumps to move fish between net-pens and for harvesting fish from net-pens. These pumps are necessary to operate farming technology such as fish graders, fish counters and automated harvesting equipment. Fish pumps and hoses come in specific sizes according to the size of fish they can pump.

Figure 3- Fish pumps are essential for moving fish around a fish farm and allow fish to be kept in water during transport. (Vaki Iceland 2020)

b) **Current State of Technology in Ontario:**

Net-pen sites in Ontario have only started to embrace fish pumps in the last five years; their current use is not widespread. Companies with pumps move them around to multiple sites, to where the need is greatest, still leaving much labour to be done. Much fish transferring is still done by hand or seine net while the fish pump is in use elsewhere in the operation. Some locations have no pumps and use workers netting fish exclusively for their fish moving and harvesting.

c) **Opportunity for Technology Upgrade Implementation to Reduce Potential COVID19 Spread:**

Fish pumps eliminate the need for labourers to be congregated together working shoulder to shoulder to harvest fish. Without the use of a fish pump, fish are seine netted up close to the walkway and workers use dip nets to pull fish from the water and place them in the harvest boxes behind them. The work is labour intensive and requires 6-8 harvesters (depending on harvest size) working together in close proximity. Pulling fish from the water is physically exerting and members must switch roles as they get tired. Using a fish pump eliminates most of these individuals from the job. 2-4 people can handle the harvesting event and maintain physical distancing.

d) **Technology Options Available to Industry:**

Fish pump technology is well developed and widely available. There are many companies that will provide fish pumps of different styles and sizes. Fish pumps are designed to work inline with other technologies such as fish counters and graders. There are many styles and models available to match applications including electric and gasoline models. Pumps are usually mounted on carts or trailers but can be fixed in place or attached to a boat as needed.

The larger and more powerful the fish pump the more expensive. The smallest models for fingerlings start at approximately $20,000 CAD, increasing with size. The net-pen farmer's greatest need is assistance with harvesting and moving the largest fish on the farm requiring farms to invest in larger much more expensive fish pumps. It is anticipated that most Ontario farmers will require the larger 10" models that can move fish up to 5 lbs. These models retail for upwards of $130,000 CAD.

Demonstration of fish pump operation suitable for Ontario net-pen sites:
https://www.youtube.com/watch?v=8ih0FBPnGA8

e) **Comparable Sites and Operations Using this Technology:**

Salmon farming net-pens on both coasts extensively use fish pumps in their operations and have for more than 25 years, so extensively that fish pumps have been adapted into specialized farming technology. Specialized harvesting vessels use built in fish pumps to move fish from the net-pens into the harvest boats. Well boats and transfer work boats use built in fish pumps to move fish from net-pens to their hold or to other net-pens. Anytime a fish is moved on a net-pen in the salmon industry, a fish pump is used, and handling is minimized. The same can be said about the UK trout industry farms on the Scottish lochs, fish pumps are used almost exclusively. Typically, large fish pumps mounted on towable carts or mounted to work boats are used in the European trout industry.

f) **Co-benefit to Sector:**

An immediate reduction in labour needs and increased harvesting efficiency provided by acquiring fish pumps would be a big boost for Ontario's net-pens. Fish pumps are used frequently by net-pen operators who harvest multiple times per week throughout the year. Between harvesting and

moving fish, a fish pump is an essential piece of equipment that makes a big impact in performing everyday farm tasks. Fish pumps are also essential for using many other pieces of fish farming equipment. Once fish are being pumped through a hose, they can be pumped through anything, such as a counter or harvesting machine. Without a pump it is not feasible for the farmer to even attempt these regular farming processes at a net-pen site.

g) **Effect on Current Local Workforce:**

There are no special skills needed to setup or operate a fish pump. Fish pumps are designed to be simple to use and setup allowing current employees to learn fish pump operation in an afternoon. Seining skills already in use at the farms are used to crowd up fish for the fish pump. Fish pumps are built to be easy to move around and easy to operate.

h) Feasibility Rating: 9.14

Fish pumps for net-pens score high in each category. Fish pumps drop the risk of COVID19 transmission significantly by eliminating netting and carrying activities that require close quarters labour. They are easy to use and easy to implement, not requiring installation because they are portable. This technology still comes at a high cost, especially for harvest size fish.

2. Centralized Automated Feed Systems

a) **Background:**

Centralized automated feed systems are the most effective and efficient way to feed net pens. These types of systems have been the standard for high capacity feeding for the last 15 years at ocean net-pen sites. Atlantic salmon net-pen farmers on both coasts run centralized feeders exclusively, complete with camera systems.

Feed is loaded into silos (holding containers) at a central point and is distributed by blowers (fans) through hoses to the destination fish net-pen. At the net-pen, the feed is shot out by a nozzle that spreads the feed evenly across the surface of the net-pen where fish consume it. The automated and centralized nature eliminates workers moving feed and feeders from the storage area to the net-pens. The silos make moving and loading feed much easier, eliminating the need to lift large amounts of feed to load feeders.

Centralized feeders require control computers and programs to run them and must be operated properly with constant observation to be effective. The addition of underwater monitoring cameras completes the centralized feed system by allowing the farmer to monitor feeding fish below the surface and stop/slow/speed up the feeders as needed.

b) **Current State of Technology in Ontario:**

There are currently no centralized feed systems on Ontario aquaculture net-pens. Current systems are a combination of throwing feed by hand and various mobile blower feeders. These blowers are labour intensive and involve using a mobile feeder to visit each net-pen. Current feeders have low capacity (400-500 kg max) and must be filled multiple times per net-pen of fish. Workers go back and forth keeping the feeders supplied with feed. Some sites have conveyers and feed silos to store feed and load feeders quickly. The number of blower feeders at each site is limited and they must be shared between multiple net-pens. Current methods are inefficient and labour intensive. These methods lead to uneven growth and prevent the farmer from maximizing stock growth- meaning smaller size and less value at harvest than could be achieved with more efficient feeding systems.

Figure 4- Blower feeders hold small amounts of feed and must be moved between net-pens.

c) **Opportunity for Tech Upgrade Implementation to Reduce Potential COVID19 Spread:**

Adoption of a centralized feed system would reduce the possible transmission of COVID19 from two events- moving feed onto the system and feeding fish. With a centralize feed system no farms would need to use human-power to load fish feed onto the system. Workers would not have to work together to move feed onto the system, to load hundred of kg of feed bags into feed blowers and it would eliminate the need for the feed blowers to run back and forth from the system to the central feed point.

Much of the handfeeding would be eliminated, especially that for the smallest fish on the site who require feed too small for the current blowers. These small fish require large amounts of handfeeding by multiple technicians on the system. A centralized feed system would drop the need for feed labourers and allow most of the feed to be done by the feed system. The addition of cameras would increase protection by dropping the number of people needed to feed a farm to one person who can sit in an isolated control room and work the feed system through the cameras.

d) **Technology Options Available to Industry:**

There are many suppliers that offer centralized feed systems. All systems offer the same general features and are custom designed for each farm site. Systems are highly customizable with many options available for silos, farm size, net-pen size, and logistic setup. Systems can be setup for surface or subsurface feeding. Each feed system comes with a control system and software for operating the fish feeders and stock management. Feeding is controlled via a software terminal consisting of several monitors and camera feeds.

Feed is loaded into the silos in the central warehouse with a forklift or conveyor system. The feed technician sets how much feed is being delivered throughout the day in the software. The feed technician watches the monitors or net-pens to ensure feed is being distributed properly and check fish feed response and make changes to the feeders as needed. The system can be setup on land beside a net-pen farm or in a specially designed feed barge that houses all equipment and feed in one floating unit.

Many of the suppliers offer technology to improve the use of their feeders for farmers. Cameras to view underwater feeding and fish behaviour greatly improve feeding and stop waste feed. Stock

management tools and in situ water quality sensors can be integrated into the system to ease data collection and provide real-time monitoring.

Cost is the biggest factor holding back implementation in the Ontario net-pen sector. Centralized feed systems are used by large companies (coastal salmon farms) who buy integrated systems they use to feed and monitor dozens of sites in their companies. For the much smaller companies of Ontario the initial start-up cost of the feeding system alone is prohibitive. The most economical bare bones system $200,000-$700,000 to purchase and install *for each site*, depending on the size and needs of the individual sites. For a top end centralized feed system with a feed barge featuring storage and control units with underwater cameras the cost would be $1.7-2.0 million per site.

e) **Comparable Sites and Operations Using this Technology:**

Centralized feed systems are used extensively in coastal salmon farm net-pens and have been for the last 20 years. The adoption of automated feeders and cameras revolutionized salmon farms increasing efficiency, growth and harvest weight while greatly decreasing wasted feed. These systems have greatly helped to alleviate labour shortages at coastal farms. These feed systems continue to advance their technology at a rapid pace with artificial intelligence recently being introduced to the camera systems to accurately determine fish size and biomass.

f) **Co-benefit to Sector:**

Adoption of a centralize feed system in any form will immediately increase the farm's ability to feed more efficiently. Any upgrade purchases (like underwater cameras) will continue to increase efficiency on the farm. Fish will be larger at harvest because more feed will be delivered and delivered in a much more efficient fashion. Number of workers needed to feed the fish will be greatly decreased and workers will not have to balance their time between feeding and other tasks. Feed will not have to be taken out to the net-pens on trailers and pallets. Loading hoppers will be much easier, their central location allowing forklifts and conveyors to be used instead of muscle power alone.

The adoption of large feed silos will allow sites to buy feed in 1-ton bags instead of 20kg bags, eliminating not just the labour of moving and loading 20kg bags but also the plastic waste. 1-ton bags can be loaded by forklift into hoppers that load into the silos by one person. Site productivity increases in every way with a centralized feed system, it is a higher level of farming- more efficient, effective, and environmentally responsible- moving away from the old way of labour-based fish feeding.

g) **Effect on Current Local Workforce:**

The greatest effect on the workforce will be a reduction in the amount of time and labour needed to provide feed. An entire site can be fed by 1-2 people, depending on how much hand feeding is needed, instead of 4-8. Operating and maintaining the feed system takes training. Most feed system suppliers offer staff training as part of their purchasing package. A background in aquaculture is important for running the control software and specialized staff may need to be hired to operate the system. Running a centralized feed system at an Ontario net-pen farm will help to attract workers. By advancing feeding technology to the industry standard, more graduates and candidates will see the need for their education and specialized training on Ontario net-pens and not see themselves as labourers hauling and lifting all day.

h) **Feasibility Rating:** 7.14

Feed systems score high for labour reduction and long-term efficiency impacts on the farm. Both these benefits significantly reduce the risk of COVID19 transmission. The large initial cost, and the

customized and complicated installation process detract from the score. Specialized training is required to run the system would have to be added to the labour force.

3. Materials Handling

a) **Background:**

Materials handling equipment is key in any operation to move large items efficiently and safely. Items like fish feed or boxes of harvested fish are packaged onto pallets (skids). Pallets are designed to be versatile and many options are available to move these around. Pallet jacks for warehouses, forklifts and cranes are three good examples of how companies use technology to move palleted goods. Tons of feed come packaged on skids and as each site will feed multiple tons per day, it is a significant amount of work moving feed shipments into the feed warehouse and then to feed the fish. Tons of harvested fish are put in tote boxes on pallets, fresh ice comes on pallets, equipment comes palleted- the equipment used to move large items at a farm has a direct correlation with the efficiency and productivity of a farm.

b) **Current State of Technology in Ontario:**

The nature of net-pen operations in Ontario requires a large amount of labour to move and load material and products. Because of the diversity in farms setup in Ontario, material handling varies from site to site. Some farms are attached to land with road access, some sites have floating net-pens near but not attached to land, other farms are attached to islands with no road access. Setup determines how materials need to be handled. Land based farms use forklifts to move materials around the land but not on the system itself. Pallet jacks and ATV trailers are frequently used to move materials on net-pens at island-based sites. Tons on pallets require 2-3 people to move them up ramps and across hinged net-pen system pieces by conventional pallet jacks. The weather can make handling even more of an issue with wave action and slippery conditions caused by rain and splash. Few sites have electric or gas-powered jacks that can be operated by one person. The two most frequent heavy materials handled are fish feed (everyday) and harvested fish (2-7 times per week).

i. **Feed Handling**- Feed tons arrive by truck, are unloaded by a forklift, and placed in a secure feed shed at each site. Island-based sites load their feed on a barge with the forklift/pallet jacks and deliver the feed to the island site where its is unloaded with pallet jacks into a secure feed shed. Without a centralized feeding system sites must use some form of labour to get feed to fish. Feed must be moved out to the system to be fed through blower units. Some land sites have installed feed storage silos. Towed feeders can be driven up to the silo or feed boats can be docked below the silo for gravity filling and driven out to the net-pen for feeding. At sites without holding silos, feed tons must be moved out to the fish net-pens with pallet jacks and muscle (or powered jacks if available) or broken down into partial tons and loaded onto ATV flatbed trailers.
ii. **Harvested Fish**- Harvested fish are stored in 1 ton plastic tote boxes on pallets. They are moved with jacks onto shore for pickup with forklift, or for island sites, moved onto a boat or barge with pallet jacks and then off again when they reach shore.

c) **Opportunity for Technology Upgrade Implementation to Reduce Potential COVID19 Spread:**

Materials handling equipment can go a long way to reducing the spread of COVID19 by eliminating the need for workers to move materials by hand, which requires people working close together. Currently fish totes and feed pallets are moved by the labour force in and out of feed sheds

and onto boats, which requires a team of people. Many options are available to reduce this congregation of workers and use machines to drop the need for a concentrated labour force to move materials.

d) **Technology Options Available to Industry:**

The are many potential solutions to materials handling around aquaculture net-pens in Ontario. Without the adoption of centralized feed systems, farms need to use efficient ways of moving fish feed with less labour as well as totes and equipment. There are many possible materials handling solutions, three examples have been selected here but each farm will have its own need and solution.

a. **Power jacks**, both electric and gasoline, come in many sizes from many manufacturers, including off-road varieties. Power jacks use a motor to move palleted tons around, instead of relying on human power. While some farms have a few of these items they are not widespread enough to greatly offset labour. These jacks are shared between sites and are moved around to where the item is needed most, there are no spares. With power jacks working at each site, labour for moving feed and fish can be greatly reduced. Instead of 2-3 people pushing a conventional jack, one person can move the materials with a power jack.
b. **Cranes**- several operations would benefit greatly by installing a crane on their boat to pickup and unload pallets of feed and fish from the deck. A crane installed on a large work boat or barge can easily lift each pallet on and off the boat, plus provide support lifting and pulling nets and moving equipment around.
c. **Capstans**- or rope pullers allow one person to pull enough weight for three people. Capstans can be mounted on the system or on a cart and can be portable if configured. By wrapping a rope or line around a capstan one person can safely raise large loads or anchors alone or pull a heavy seine.

Figure 5- cranes (left) and capstans (right) take the labour of moving and hauling (courtesy Salmonfarmingexpert.com)

e) **Comparable Sites and Operations Using this Technology:**

Most net-pen aquaculture operations in North America and Europe use forklifts more so than pallet jacks. Net-pen systems themselves in the ocean are much more robust and forklifts are driven around the net-pens. Ontario's farms are not designed with forklifts in mind, thus, are not strong or wide enough for forklifts to operate on. Cranes are an integral part of every aquaculture workboat at ocean sites for loading and unloading ships, they are the standard for loading and unloading freight from ships. A crane's usefulness cannot be overstated. Lucky Lake fish farm, located on Lake Diefenbaker, uses deck mounted cranes with fish baskets to eliminate dip nets from fish harvesting. It should also be noted that ocean farms do not harvest into totes, removing that logistical consideration from their

operation. Well funded ocean site companies have special designed harvest boats that perform all harvesting activities by pulling alongside the net-pen to be harvested and taking the harvested fish right on board. There is no need to load or unload boxes for fish.

f) **Co-benefit to Sector:**

Long term reduction in labour would result from adopting better material handling equipment. These technologies would release workers from the labour of pushing boxes and pallets around the system for hours a day for deployment at other tasks, making the farm more efficient overall. These technologies are significantly safer for workers, reducing the risk of strain injuries as well as slip and fall injuries that can occur straining to push 1-ton pallets along the system or up and down ramps.

g) **Effect on Current Local Workforce:**

Powered jacks will decrease the labour demand associated with moving feed, harvested fish and equipment. Power jacks are designed to be easy to use and should be familiar to any workers already using unpowered jacks. Crane operators must carefully learn their crane and take a 2-day crane operator course. Crane safety will need to be a huge emphasis with the entire workforce where they are adopted, and hard hats will need to be enforced around the crane. Capstans make rope hauling a one-person job and can be operated by any worker after a short instruction session. They are portable and versatile if needed.

h) **Feasibility Rating**: 8.34

Materials handling equipment to reduce the labour onsite is a significant step to limit the spread of COVID19. Much handling on net-pen sites is performed by muscle power which needs to be reduced. Installation ease and time, labour specialization needs, and upfront cost all vary by significantly item to item. Items like cranes are obviously much more expensive and tougher to implement than capstans or pallet jacks.

4. Humane Harvesting Equipment

a) **Background:**

Humane harvesting systems have existed for many years and are designed to operate with fish pumps. Fish are crowded together with a seine net and sucked through a hose by the fish pump into the slaughter apparatus and are humanely slaughtered by shock then slide out into iced containers for immediate transport to the processing facility. Stunner equipment using electrical shock is the industry standard for humane slaughter, however these systems are generally large and attached to a large vessel specifically designed for ocean net-pen harvesting. Recent technology has developed smaller versions of electrical stunners that are more adaptable and portable for use at trout farms. These smaller scale applications have seen widespread adoption at UK trout farms where humane slaughter legislation is stricter than in Canada. Canada is looking to tighten this legislation as well and the industry needs to be looking at a new model for harvesting (Rich Moccia pers comm).

Humane harvester demonstration page: https://www.smith-root.com/aquaculture/humane-fish-harvester#

b) **Current State of Technology in Ontario:**

There are currently several approved methods for fish harvesting in Ontario: a) Percussion blow; b) electrical shock; c) electrical shock to render the fish senseless followed by pithing (piercing the brain) or exsanguination (bleeding); d) percussion blow followed by pithing or exsanguination; and e) ice bath immersion. Net-pen farmers in Ontario use ice bath immersion exclusively as it is the only method that can work with large volumes of fish without highly specialized equipment. There are no automated percussion or electrical stunners in Ontario.

Ice bath immersion involves the fish being removed from the net-pen by dip net or fish pump (if available) and put into an ice slurry where they are stunned by the shock of the cold water. Legislation around ice bath method is changing in Canada and other methods of euthanasia will have to be added to the production cycle to replace ice baths going forward. Land based operators in Ontario use handheld percussion stunners or a handheld club to euthanize their fish before processing, which is very labour intensive.

Figure 6- Harvesting manually with dip nets is labour intensive as is ice bath slaughter. (OAA 2018)

c) **Opportunity for Technology Upgrade Implementation to Reduce Potential COVID19 Spread:**

Adopting humane fish harvesters would fundamentally change the way farms harvest fish and remove the risk of transmission during harvesting events. By using a humane harvester there would be no need for workers to be congregated to remove the fish from the net and no need congregate to run the traditional ice baths. This would remove hours of contact time by employees each week where the virus could spread.

d) **Technology Options Available to Industry:**

Technology available to Ontario net-pen farmers has developed enough in the last few years to consider widespread adoption in Ontario. Harvesting equipment is expensive in every way, a base model starting at $175,000-200,000 CAD. The UK does not allow ice bath euthanasia and their industry has adapted by adopting portable scaled down harvesting technology that work for their operation. For years harvest equipment has focused on large scale ocean salmon farms where the harvesting equipment is designed for operation on a larger scale, much larger fish and integrated into a vessel with the sole purpose of harvesting salmon.

New scaled down models can be mounted to a work boat, or on a trailer or cart for portability. These models are designed specifically for rainbow trout and would be adoptable at any site using a fish pump. These units come in different sizes. The larger size, with the largest footprint is setup to electrically shock fish to death. Small units, with a smaller footprint, can be setup as a stunning device to render fish senseless before they are euthanized by exsanguination.

The units are versatile enough that operations attached to the shoreline or just offshore will have no issues pumping fish into the harvester. Boat or barge mounting is the most obvious answer for

operations with island-based farms that would work for all other net-pen sites as well. These units are adaptable enough that the farmer can decide what works best for them and mount accordingly. Fish are pumped in and out of the unit allowing the operator to setup in an optimal location and locate the fish totes in an optimal location for minimal labour. Harvesting fish becomes a seamless process as the euthanized fish are consistently pumped into totes without wrestling dip nets, lids, jumping fish and switching out boxes within reach. The chute or hose is simply moved to the next tote once one is filled.

e) **Comparable Sites and Operations Using this Technology:**

As mentioned above humane harvesting units are used extensively on the coasts for salmon aquaculture but are integrated into very specialized harvest boats that service numerous net-pen sites on a huge scale. Ontario's trout farming industry is by far the largest in Canada, but its humane harvesting capacity needs falls well below the ocean-going harvest boats. The best comparable is the UK trout industry, it is similar in size and scale, they raise the same species fish, harvest at similar size and the farms are largely locally owned. Because of legislation in the UK producers adopted electric stunners because they are effective and there are few other small-scale choices available. Fish pumps are standard equipment in the UK, found on every farm, which allowed euthanasia units to be easily integrated.

f) **Co-benefit to Sector:**

Widespread adoption of this technology would greatly increase animal welfare standards for the humane killing of animals for food. Elimination of ice baths is coming, and new technology must be adopted. Combined with fish pumps, electric euthanasia units reduce the labour needed for the harvest activity and make the logistics of harvest much easier. Potential escapes and damaged fish will be greatly decreased because there will be no transfers of live fish that can struggle or flip out of the nets or tote boxes.

g) **Effect on Current Local Workforce:**

Adoption of one of these systems will reduce the number of people needed to harvest fish and make it easier to move and transport fish because the hoses make the units so versatile. Fish handling is completely removed from the harvest event. Harvesters are simple to use and made to be operated by the average farm technician, but there is necessary safety and operational training. The equipment company will train workers on the job to use the humane harvesting equipment safely and train specialized operators on the farm who will setup the machine and perform routine maintenance.

h) **Feasibility Rating**: 7.43

Humane harvesting equipment is the best way to prevent COVID19 spread while harvesting fish. Adopting a fish pump significantly reduces the labour needed to harvest, harvesting equipment decreases it even further and physically distances the workers that remain. There is a high cost to adopt these units and specialized training. Units must be custom built, and a location or vessel prepared for mounting.

5. Boats and Barges

a) **Background:**

Boats and barges are essential for work around and between net-pen sites. Boats transport staff between sites, push net-pens and provide key operational support. Barges and large boats supply feed

and transport equipment and harvested fish to and from island-based and offshore net-pens. Boats and barges are key for any operation but are essential for operations where the net-pens are not attached to the shore.

b) **Current State of Technology in Ontario:**

All farms have boats of various sizes to meet their specific operational needs. From tin boats to skiffs to barges and tugs/haulers the variety of boats changes from site to site. As operations continue to expand in Ontario, companies need to expand the size of their fleet to meet the expanded work and embrace larger barges. By adopting new technologies like fish pumps, or cranes, which are large and need to be transported around by barge, companies need more boat capacity dedicated to these technologies while maintaining current boat needs. Boats are used everyday and wear and tear is substantial. Broken down boats are a huge source of loss to farmers because the workload on their other boats must increase and logistics can become more difficult. Repairing a boat becomes top priority if it breaks down.

c) **Opportunity for Technology Upgrade Implementation to Reduce Potential COVID19 Spread:**

Transport space was an issue with boats before the arrival of COVID19. Crew boats and work boats are cramped and wet without space to allow for distancing. An expanded fleet allows farms to distance people better by transporting less people on each boat. COVID19 has damaged the supply line for boats as well with farmers reporting difficulties getting parts to repair boats and motors. Boat breakdowns further concentrate the staff on a small number of vessels.

d) **Technology Options Available to Industry:**

Boats are a universal piece of equipment that are available in hundreds of models, including custom constructed models designed to work specifically with fish farms. There are barges of all sizes to suit whatever operational needs required by a farm and versatile enough to customize with fish farming or material handling equipment. Price depends on vessel size, machinery used and customization. What type and size of boat needed is specific to the needs of the farm.

e) **Comparable Sites and Operations Using this Technology:**

North American trout operations generally purchase or build boats and barges which they customize for their need and do not use integrated technologically advanced vessels like those found in Europe or in coastal salmon farming operations. Though they are highly effective, the high cost of integrated technology and the need to purchase from overseas are strong deterrents.

f) **Co-benefit to Sector:**

Expanded fleet and barge capacity will increase the ability of the industry to embrace new technologies and provide work boats to all facets of their operation. Customized work boats and barges will allow companies to install technologies such as booms/cranes, fish pumps, fish counters and graders on a boat or barge to create a customized work solution specific to operational needs.

g) **Effect on Current Local Workforce:**

Effect will depend on boat size and choices. Greater fleet capacity will increase transport capability between sites and minimize down time waiting on boats. Work boats and barges will allow new technology to be used that decrease labour needed for farm jobs. Small vessels require at minimum a PCOC license to operate, with longer more specialized training (SVOP and masters tickets) needed as

vessel class increases in size. Depending on tonnage, specialized staff may need to be hired or selected current staff sent for education to operate large barges and workboats.

h) **Feasibility Rating**: 6.71

Boats and barges can help prevent the virus' spread by providing more space for transportation and workspaces on the water. Boats are easy to adopt but will not reduce the amount of farm labour, it will make the labour force more efficient.

B. Land Based

Land based farms in Ontario are much less uniform than net-pen farms and technology level differs across the industry. Some hatcheries in the province are significantly advanced in some technologies and have greatly increased their efficiency in the last 10 years. Even so, the technology level of Ontario's hatcheries in general lacks behind the rest of Canada and Europe. Ontario features a mix of traditional flow through hatcheries, where the water is drawn into the hatchery, passed through the fish, filtered, and returned to the source, and recirculating aquaculture systems (RAS) where the same water is passed through the fish, heavily filtered, refreshed, then passed through the fish again in a continuous cycle.

Land based operations are inherently much more expensive, complicated and technology heavy. Land based farmers must maintain the environment for their fish, providing waterflow, oxygen, filtration, and disinfection. Fish are handled and moved frequently as they are counted and graded by size. Hatcheries each have their own unique business model, goals and needs. Some hatcheries produce fingerlings for the net-pens on Lake Huron, some harvest and process their own animals, some ship their product to market live, or live for pond stocking. Only a few hatcheries produce eggs and maintain a brood stock, while most others purchase eggs or fingerlings. Ontario hatcheries include warm water niche species including Pacific white legged shrimp, tilapia, and barramundi.

1. Fish Pumps

a) **Background:**

Fish pumps are designed to transport fish through hoses to a destination, eliminating the need to capture, handle and carry fish with nets and buckets. Fish pumps are specially design so that fish pass through without touching moving parts and are not damaged by the pumps. Fish pumps are the typical piece of equipment for moving fish of every size and are used in all aspects of fish farming. Fish pumps and can move fish over long horizontal distances. In hatcheries, fish pumps are essential for using fish farming tools such as fish counters and fish graders for working with juveniles as well as for splitting and moving fish as they grow.

Fish are crowded up and sucked through an intake hose, travel the length of the hose, and are deposited at their destination without leaving the water and without being handled by humans. Because they are always held in water and are not handled, stress levels and fish condition are far superior to handling with nets. Events like loading a truck full of fish is a simple task with a fish pump- the fish are crowded up and sucked through the pump hoses into the truck. Without a fish pump staff must crowd the fish, net the fish into buckets, carry the buckets to the truck, lift the vessel to the top hatch of the holding tank, pour in the fish- one bucket at a time. Fish lose scales struggling as they are netted and transferred. As the fish sit in the bucket the oxygen is quickly depleted stressing the fish.

b) **Current State of Technology in Ontario:**

Hatcheries across Ontario vary greatly in terms of scale, species selection and technology investments made. Some hatcheries are very sophisticated and already employ fish pumps while others rely entirely on nets and buckets and use manual transport, or in a few cases gravity feeds, to move their fish around. The largest scale land-based farms in Ontario are the most technologically sophisticated and have embraced fish pump technology to lower their labour costs and better handle their fish. Embracing fish pumps has allowed these farms to take advantage of other technologies which require a pump to make their businesses more efficient and their product better. Smaller scale hatcheries are usually deterred by the capital cost of pumps and associated hoses and fittings. Without a fish pump they have limited access to other sophisticated tools and must have labourers move the fish, resulting in more handling and fish stress.

c) **Opportunity for Technology Upgrade Implementation to Reduce Potential COVID19 Spread:**

Fish pumps take the congregation of workers out of moving fish around the farms, reducing the risk of COVID19 transmission. Capturing fish with nets, moving them with buckets, pouring them through counters or graders and loading them into trucks are all labour-intensive activities that require a large labour force to work close together without physical distancing. Fish pumps eliminate most of the workers from the job and allow adequate distancing of the workers who work the fish pump.

d) **Technology Options Available to Industry:**

As mentioned in the section about net-pen site fish pumps, the technology is well-established and there are many customizable setup options available for farmers. Ontario land-based farms are diverse, and the specific fish pump needs for each farm will differ depending on how their business operates. Fish pumps run in the $20,000-150,000 CAD depending on size and species plus the cost of hoses, fittings and carts/mounting as needed.

e) **Comparable Sites and Operations Using this Technology:**

Large scale land-based hatchery operations across North America and Europe use fish pumps extensively in their operations to reduce labour and fish handling. In Canada, aside from adoption by the largest hatcheries in Ontario, juvenile hatcheries for ocean salmon farming operations use fish pumps at all their hatcheries. Operating a large-scale hatchery without fish pumps is extremely labour intensive and expensive and it is not seen in the developed world. Farms without fish pumps find themselves hitting a ceiling on their operations, limited by the labour associated with their farms, unable to move fish efficiently and make the next step to embrace improved farming technology and expand their operation.

f) **Co-benefit to Sector:**

Adopting fish pumps makes all tasks where fish are moved: a) take less time b) use less workers c) improve the fish health compared to netting d) safer with less risk of staff injury. Other technology can be used such as fish counters, fish graders and humane harvesters to increase efficiency once fish pumps are in place.

g) **Effect on Current Local Workforce:**

Fish are moved frequently at hatcheries and fish pumps remove the daunting nature from the tasks. There is less stress for the humans and much less stress for the fish. Fish pumps can be operated efficiently by 2-3 people, instead of 6-8 people carrying buckets of fish. The risk of strain, slip and fall and crush injury during these events is greatly diminished. The adoption of a fish pump is one of the first steps to attracting skilled workers to a hatchery as it is a fundamental technology. Farms that do not use

fish pumps often have a harder time attracting skilled workers because so much of the operation is labour.

h) Feasibility Rating: 9.57

In many cases, fish pumps for land-based farms are significantly less expensive because they are used on smaller fish. Fish pumps score well in every category, though some farms will already have their fish pump needs satisfied. They are easy to adopt and use and make a huge impact on operations.

2. HVAC

a) **Background:**

Heating, ventilation, and air conditioning systems provide heating and cooling to buildings. Of concern to Ontario's land-based facilities is the ventilation aspect. Ventilation systems exchange the air in a building to improve air quality by removing moisture, airborne pathogens, carbon dioxide, dust, and odors, to bring in fresh air. Hatcheries are by nature a wet environment that require solid ventilation systems. Old ventilation systems are inefficient and do not give proper air exchange which can promote the growth and spread of pathogens in the air.

b) **Current State of Technology in Ontario:**

The state of HVAC systems across Ontario's hatcheries is diverse. Newer built hatcheries have updated HVAC systems while farms with older buildings may or may not have updated the HVAC systems. Hatcheries by nature have many buildings and rooms such that the state of HVAC is not uniform. Many farms have locations where upgrades need to be made to the HVAC system for a particular space, room or building. "Tired" ventilation systems can be found at older farms that have become inefficient and outdated. HVAC systems usually last 15-25 year but can vary significantly based their environment.

c) **Opportunity for Tech Upgrade Implementation to Reduce Potential COVID19 Spread:**

Health Canada has identified ventilation systems as having an important role in reducing the transmission of COVID19 indoors and poor ventilation has been linked to several outbreaks in Canada (Government of Canada 2021). Hatcheries have many tight locations such as eggs rooms and processing rooms. Increased ventilation anywhere on the farm, particularly in smaller spaces where workers crowd can prevent the buildup of aerosol COVID19 and reduce the chances of transmission.

d) **Technology Options Available to Industry:**

HVAC systems exist in most buildings; many solutions exist to suit any building or space. Because of the custom nature of HVAC to the building, the solution will depend completely on the size of the space and the needs of the farm. Price will vary with the size of the project and space. Because of the vastly different needs of each hatchery, it is difficult to estimate price.

e) **Comparable Sites and Operations Using this Technology:**

New buildings, including hatcheries and fish processing facilities, are setup with a powerful ventilation system to provide good air quality and discharge pathogens. Cole Munro's processing plant in St. Thomas Ontario is a good example of a new building with a state-of-the-art HVAC system that provides excellent ventilation to keep workers and product safe from pathogens in the air. Ventilation

systems are combined with heating and cooling units or filters in many cases, thus the need for a custom solution for each farm.

f) **Co-benefit to Sector:**

HVAC upgrades would provide a long-term improvement to air quality, updating old heating and cooling system as well as the ventilation. More moisture reduction keeps everything much drier and less prone to rust and rot.

g) **Effect on Current Local Workforce:**

HVAC upgrades would have no effect on current workforce needs.

h) **Feasibility Rating:** 5.93

HVAC units score well for preventing COVID19 spread but installation is expensive and can be intrusive, and there is little benefit to farm productivity or labour force.

3. Fish Counters/Graders:

a) **Background:**

Fish counters and graders are well established fish husbandry tools used at most fish hatcheries. Fish counters and graders are often used together to sort the fish by size and provide accurate fish counts for stock management and feeding. Both counters and graders are essential tools for any large fish hatchery. Using counters or graders without a fish pump is possible but problematic: stressful on the fish, slow and labour intensive.

Fish Grader: A fish grader sorts fish by size. Fish are pumped into the grader with a fish pump where they fall through different sized slots based on fish size. Beneath each slot is a tube that sends the fish to a separate fish tank. If a counter is being used in conjunction with the grader, fish are counted as they enter their tank. Grading fish is an essential exercise at any fish hatchery, especially in species with cannibalism issues. Grading promotes fast growth and decreases feeding competition between fish. Keeping fish of the same relative size together allows for proper feed selection. Species with a penchant for cannibalism, like barramundi, need to be graded frequently. The greater the size variation of fish in a tank the greater the chance and effect of cannibalism.

Fish Counter- Fish counters use sensors and software to count fish as they pass through the sensing area. Counting technology is very well developed and counters are available in various models and styles. Counters are designed to be used with fish pumps and used whenever fish are moved. Counters allow the farmer to know exactly how many fish are being delivered to a tank or location and cut off the flow of fish once a target number has been reached. Counters increase the farmers ability to manage their stock because of the excellent accuracy of the counters. Accurate fish numbers yield accurate biomass numbers which allows for the most efficient feeding. Fish can be counted frequently so farmers have a good idea throughout the growth cycle and do not have to estimate or guess their stock size.

Figure 7- Fish pump-grader-counter system used to count fish and sort them by size (Vaki Iceland 2020)

b) **Current State of Technology in Ontario:**

Much like fish pumps, fish graders and counters are used by the largest hatchery operations in the province to offset their labour, reduce fish stress better manage their stock, but are not embraced by the smaller operators. Smaller operations make use of small-scale counters and graders without using a fish pump, using labour to load manual fish graders and counters. The process is so labour intensive without a fish pump it is prohibitive, thus, these tasks are not done frequently with large groups of fish.

c) **Opportunity for Tech Upgrade Implementation to Reduce Potential COVID19 Spread:**

Hand counting and hand grading fish is labour intensive, requiring employees crowd up fish and run them through manual graders with nets and buckets. Adopting a grader or counter takes the manual labour out of these activities and allows the labour to be done in conjunction with other activities by fish pump operators. There is minimal risk of transmission because physical distancing can be maintained and the work force for grading and counting becomes much smaller.

d) **Technology Options Available to Industry:**

a. Grader prices vary based on number of fish per hour that it can grade and the size range of the fish that it will accept. Small scale graders still have a large price tag at $20,000 CAD for the smallest model. Farms that purchase the smaller models soon find themselves wanting to upgrade once they get used to working with a fish pump and look to expand. The largest capacity fish graders retail for $250,000-300,000 CAD. Graders can be mounted on trailers or carts or fixed permanently in place as need demands.
b. Counters also have a high price tag, but cost is not as prohibitive as fish graders. Price is largely based on fish size and the number of fish that can be counted per hour. There are many models that are portable and affordable, but their usefulness to the farmer depends on application. Portable counters can be bought for $6,000-12,000 CAD. More sophisticated counters for counting large numbers of fish quickly are much more expensive in the $130,000-150,000 range for a base model using top of the line technology.

e) **Comparable Sites and Operations Using this Technology:**

Any large-scale hatchery operation in North America or Europe uses sophisticated fish grading and counting technology. Coastal Atlantic salmon hatcheries use counters and graders extensively for rearing juvenile salmonids and preparing shipping groups. Counters are used on well boats and transports for counting fish on and off trucks and vessels. European fish farms also have regular grading and counting regimes to split their stock and count fish for density and order shipping.

f) **Co-benefit to Sector:**

Investment in counters and graders improves a farms ability to manage their stock, feed efficiently and get the best biomass growth. This is necessary technology for a hatchery to grow in scale and output for fingerling production.

g) **Effect on Current Local Workforce:**

Counters and graders are labour heavy if used without a fish pump. With a fish pump these events are much easier, more effective, and gentler on fish. Counter/grader operators will need training to setup, calibrate and maintain the technology. Training is usually provided by the manufacturer or distributor to one or two staff members who will run the software and setup the technology. Those staff members in turn train the rest of the farm workers to work with the equipment.

h) **Feasibility Rating:** 6.93

Compared to other technologies, fish counters and graders only partially help stop the spread of the virus, by providing better distancing, but labour reduction and efficiency are limited unless used with a fish pump.

4. Egg Sorters

a) **Background:**

Egg sorters separate live and dead eggs at a rapid pace and reduce the labour needed to keep eggs clean. For high volume egg production facilities, egg sorters are a huge time saver. Eggs are loaded into a box which feed the eggs through the machine, each egg is scanned, and dead eggs are ejected via compressed air through a hose. Egg sorters can be fitted with a counter to count the number of dead and live egg put through it. Egg sorters can process 100,000-1,000,000 eggs per hour depending on the model.

Egg sorter demonstration video:
https://www.youtube.com/watch?v=S2JqvOC5Ssw&feature=emb_imp_woyt

b) **Current State of Technology in Ontario:**

Egg sorters are not widely used in Ontario. The high capital cost is restrictive to smaller operators. The largest trout egg producer in the province uses sorters to offset the labour of picking eggs, though few others do. Many facilities pick eggs by hand or simply purchase fingerlings. Handpicking fish eggs is labour intensive and done in a dedicated incubation room with light and environmental controls. Fish eggs must be cool, so incubation rooms are small and wet by nature. Workers open the incubators and pick through the eggs with forceps to remove the dead eggs.

c) **Opportunity for Technology Upgrade Implementation to Reduce Potential COVID19 Spread:**

Egg sorting technology will reduce the risk of COVID19 transmission by significantly reducing the labour needed for egg room upkeep. By dropping the labour needed for egg picking and keeping, fewer employees need to work together to provide egg care in the confined space of the egg room.

d) **Technology Options Available to Industry:**

There are many models of sorter available, but only a few with proven track records for reliability. Sorters are adaptable and able to be used with different species by changing egg receiving plates to suit the size of the eggs. Sorters are usually purchased with a counter to help with egg and incubator management. Sorters are expensive which prohibits their adoption by small farms. Sorters are not sold in scaled-down sizes, most companies only have one or two models so regardless of application or scale, so costs are relatively the same. Most sorters retail for approximately $100,000 CAD.

e) **Comparable Sites and Operations Using this Technology:**

Sorters are common at any facility dealing with large volumes of eggs. Egg production and brood facilities for trout and salmon across North America and Europe use egg sorters to process large numbers of eggs for shipping. Large scale egg production is near impossible without a sorter.

f) **Co-benefit to Sector:**

The labour needed to upkeep, and process eggs can easily be offset using an egg sorter. An egg sorter cuts the labour needed such that many more eggs can be reared with the same amount of effort, allowing egg production to expand without increasing staffing. Sorters do a much more thorough job of removing dead eggs than human pickers.

g) **Effect on Current Local Workforce:**

Egg sorters are small units and can be easily operated by one person cutting the workforce need. Training for staff will be provided by the manufacturer or distributor such that the unit can be setup and calibrated. After setup, the egg sorter is easy to use with minimal training. Manual egg picking is an undesirable job which can be difficult to staff, sorters make this job much more appealing and less daunting, especially in operations that produce many eggs.

h) **Feasibility Rating:** 8.21

Despite their high cost, egg sorters would protect workers from COVID19 in the small egg room. They are simple to use once setup and drop the labour needed significantly to allow for adequate distancing. An egg sorter allows a farm to increase egg production while keeping labour costs minimal.

5. Centralized and Non-centralized Automated Land-Based Feed Systems

a) **Background:**

Feeders for Land based farm fall into two categories: centralized automated systems, and automated systems. Centralized automated feed systems are “smart” technology while automated feeders are “dumb” technology.

Centralized feed systems for hatcheries follow the same principle as feed systems for net-pens. Hoppers and feed silos at a central location send feed via blowers and hoses to the tank where feed is sprayed out a nozzle onto the surface of the water for fish to feed on. Feed storage is located nearby the feed silos for easy loading at the central location. Feeders are controlled by operators using computer software to control the amount and interval of feed. Hatcheries require custom systems to adapt

automated feeder to the farm: they are much less uniform than net-pen farms and require different setups to properly feed raceways, round tanks, and systems in multiple buildings. There are many models of centralized feed systems both large and small with different silo setups and different distribution heads to spray, project or drop feed to fish. The feed technician sets how much feed is being delivered throughout the day in the software. The feed technician then monitors the fish tanks to ensure feed is being distributed properly, checks feed response by hand feeding and make changes to the feeding schedule as needed.

Automated feeders (not centralized) only turn on and off- they are feeding out or they are not. Filling automated feeders is much more a job than filling centralized feed systems as feed must be taken out to each feeder and poured into the feeder. Feeders often must be filled multiple times per day. Automated feeders may be controlled by a central computer or are set with timers. Computer controls for automated feeders lack the depth, programming and fine control that can be achieve from a centralized unit.

b) **Current State of Technology in Ontario:**

Centralized feeders are not heavily embraced at Ontario hatcheries. One large warm water facility makes extensive use of centralized feeders while most other facilities use a combination of hand feeding and different types of automated (but not centralized) feeders. Automated feeders do not use feed from a centralized point or a central blower to move feed, instead each feeder has its own hopper/silo that is filled.

There are many styles and models of automated feeders suited to different life stages and rearing containers. Handfeeding involves employees throwing scoops of feed to the fish and is used heavily at some farms. Handfeeding allows employees to observe their fish thoroughly while they are feeding and control the amount of feed but is time consuming and it takes many humans to deliver the amount of feed a centralized system can provide in a day. Automated feeders to supplement handfeeding is the strategy employed by many Ontario farms. Whereas employees would handfeed to supplement the centralized feed control system, employees use automated feeders to supplement hand feeding.

c) **Opportunity for Technology Upgrade Implementation to Reduce Potential COVID19 Spread:**

Centralized feed systems reduce the need for employees to move feed to the system and share a collective space where feed is located. Using feeders reduces the amount of work needed to feed the fish and the number people and trips by staff to the feed building. With a centralized system, one person can load all the feed into the silos each day. Without a centralized feed system, correctly sized automated feeders at the tanks will limit the number of trips between the feeders and the feed shed, reducing its potential as a transmission point. Any kind of feed system will drop the number of employees needed to feed, reducing the potential transmission between workers at the feed shed and working together to feed fish.

d) **Technology Options Available to Industry:**

There are many distributors that offer centralized feed systems. All systems offer the same general features and are custom designed for each farm site. Each feed system comes with a control system and software for operating the fish feeders and stock management. Feeding is controlled via a software terminal consisting of several monitors. Feed is loaded into the silos in the central warehouse with a forklift or conveyor system. Centralized feeders start around $200,000 CAD for a scaled down minimalist model with price increasing with scale and difficulty of installation.

There are many styles of automated feeders at various prices, they can be found as low as $400.00 CAD for low-capacity mechanical fry feeders, up to several thousand per feeder depending on control units, size, feeding rate and distribution style (air blast, auger, spinner).

e) **Comparable Sites and Operations Using this Technology:**

Centralized feed systems are common at any new or recently upgraded land-based fish production hatchery where there are many fish to feed. Smolt production facilities owned by Atlantic salmon farmers on both coasts run centralized feeders for their egg to smolt (fingerling) production hatcheries. MNRF sites in Ontario use centralized feed systems to feed their stream enhancement fry and fingerlings in some facilities.

f) **Co-benefit to Sector**:

Centralized and automated feeders reduce the human effort needed to adequately feed fish and greatly increase the potential output of feed each day. Properly sized and used feeders will increase efficiency and fish growth. The software associated with centralized feed unit gives the farmer the ability to track the amount of feed in the silos, fish growth and feeding and can provide analysis of feeding trends and feed usage. Automated feeders, especially high-capacity automated feeders can be a huge benefit to farms where much of the feeding is done by hand or by antiquated automated units. Many farms have units bought years ago that are obsolete with today's feeding and husbandry and are more of a burden to use than a benefit.

g) **Effect on Current Local Workforce:**

Feeder upgrades of any kind will reduce labour needed to provide feed. Automated feeders are easy to fill and maintain but trained staff are needed to run the control program if the feeder has one. Centralized systems are more complicated to run. The software for control and analysis requires training in aquaculture to operated and understand, plus training provided by the distributor/manufacturer. Silos for centralized feeders may require forklift training for loading depending on model and design.

h) **Feasibility Rating:** 7.14

Feed solutions for land-based farms are much more diverse than net-pen systems and feasibility depends on the technology selected. Centralized systems are more effective but expensive, automated feeders alone are less effective but come at much less cost.

6. Monitoring and Control Units

a) **Background:**

Monitoring and control units is a diverse group of system sensors and system controls used to keep track of fish life support systems, water quality and associated equipment. These sensors are run through control units and displayed on a series of central monitors where alarms and control thresholds for parameters can be set and manipulated. Advanced setups have controls for equipment available at the central monitor station. Monitoring and control units provide information in real time and are designed to avert catastrophic disaster. Alarms for equipment such as pumps, filters, blowers, and disinfection units are used to alert staff to system failure. Realtime environmental sensors monitor parameters such as oxygen, temperature, pH, tank water level, water flow and will go into alarm if any reaches critical level. These systems allow staff to get a snapshot of the facility in real time and allow problems with the water system or fish to be identified and rectified right away.

Alarms are an integral part of any monitoring system and allow technicians to be alerted to any problems remotely, after hours and offsite. Once a core monitoring and control system is in place, sensors can be added to the system piece by piece, to defer cost and grow the monitoring system over time. Base systems can be standalone systems dedicated to the fish rearing system or the fish systems can be added to larger building control units that control building HVAC and water systems.

Figure 8- Monitoring and control system (AKVA 2020)

b) **Current State of Technology in Ontario:**

Monitoring and control units are installed to some degree at many of Ontario's hatcheries. Basic alarm systems are present at most hatcheries, more sophisticated hatcheries have more comprehensive monitoring and control. Because the systems are built piecemeal every facility has sensors that can be added to provide better monitoring and security. There are many handheld units in use for monitoring in Ontario which give accurate reading for the water parameter they are designed for, like oxygen, but they do not give real time information to a central location and must be operated by a technician on the spot. Without monitoring and control units in place employees must work together to identify problems in the system and use handheld units to monitor conditions constantly.

c) **Opportunity for Technology Upgrade Implementation to Reduce Potential COVID19 Spread:**

Monitoring and control units will help prevent the spread of COVID19 by eliminating the need for staff to work together to discover issues, perform constant monitoring tasks and will allow adjustments to be made at the control unit. More information from sensors allows workers to see problems starting in real time and make system adjustments to correct the problem before a situation occurs where employees must be deployed together to fix problems and maintain the fish.

d) **Technology Options Available to Industry:**

There are many monitoring and control units available. Large corporations like Honeywell offer building control solutions and sensors with maintenance and service contracts, but do not have a background in aquaculture. More popular are aquaculture specific monitoring and control units from aquaculture-oriented companies who make units and sensors designed and tested for use with fish and aquaculture systems. Hatcheries are particularly interested in oxygen sensors and automated oxygen backup systems, flow sensors to detect water movement and height and alarms for these parameters and their life support equipment. Base system setup without any probes monitoring starts at $150,000 CAD.

e) **Comparable Sites and Operations Using this Technology:**

Hatcheries across North America and Europe have some control and monitoring system. Only the most primitive and small-scale hatcheries dare run without a system. The sophistication of these systems increases with the sophistication of the farm, each new piece another layer of protection for the fish and a better environment for them to live in. Basic oxygen monitoring is present at nearly every farm. Coastal hatcheries that produce Atlantic salmon have advanced monitoring units and state of the art sensors and alarm systems with multiple redundancies. The more important the system, the more investment is put into the monitoring and control. For example, the oxygen control system at coastal farms is advanced such that it senses the oxygen is too low and automatically starts to release more oxygen into the tank to sustain the fish and sends an alarm to the technician to respond to the low oxygen situation.

f) **Co-benefit to Sector:**

Any further increase in monitoring and control systems makes the farm more efficient by helping to identify problems and trends in the facility. Upgrades and new sensors/controls provide each provide a layer of insurance that is much needed when working with aquatic species who depend on an artificial environment. Being able to identify problems and see parameters in real time the farmer can act with conviction to solve problems and address issues before they become catastrophes, instead of having staff investigate and explore the system to find the problem.

g) **Effect on Current Local Workforce:**

Monitoring and control units require specialized training to operate. The more sensors and monitoring systems added to the control the more complicated and steeper the learning curve. Training manuals and on-site training from the manufacturer are included to educate hatchery staff. A background education in aquaculture or biology is valuable to understand and setup the monitoring and control system but is not required to run the system day to day.

h) **Feasibility Rating:** 6.36

While of great benefit to the operator in the long and short term, a control and monitoring system has limited value to stop the spread of COVID19 and is expensive and complex to adopt.

7. Accessibility Controls / Biosecurity Controls

a) **Background:**

Accessibility and biosecurity controls are physical barriers such and fences, gates, rooms used to direct the flow of human traffic and restrict access to a facility. A gate with an intercom system is a good example of accessibility controls. Accessibility controls direct the flow of traffic, forcing drivers through a designated path to enter the facility at a controlled access point. The second function of accessibility control is to prevent members of the public from letting themselves onto farms and walking around unaccounted for, again, forcing them to a controlled access point. People frequently show up at fish farms with business inquiries, questions about farms or just wanting to buy a bunch of fish.

Biosecurity controls are a type of accessibility control built with biosecurity in mind, designed to prevent aquatic diseases from being brought onto the farm by people. A biosecurity access point is essentially a disinfection station setup to force all personnel, staff or otherwise, through a controlled access point where they are disinfected before entering the farm. Specifically, for fish farms, hands, feet, and clothing. Biosecurity rooms often require people to change their footwear and coats and disinfect their boots and hands before entering the farm.

b) **Current State of Technology in Ontario:**

Accessibility at Ontario farms varies between facilities. More remote locations usually have less accessibility controls in place. Facilities close to or situated in large centres are usually fenced in to prevent vandalism and theft. Gates and more sophisticated forms of control like intercom systems and key card access points are located on only a few farms in Ontario. Each farm has their own solution to limit access based upon farm layout, but not necessarily the equipment and structure to make it effective. Curious members of the public are still an issue for some locations. People who feel they can walk around a farm or knock on the door and buy some fish, made even more dangerous by their disregard for the pandemic, continue to show up at Ontario farms and facilities.

Biosecurity controls exist at many farms, but the practice is not standardized, each facility looks to its own biosecurity needs as it feels necessary. Some have controlled access points with footwear changes and disinfection station, while others have small disinfection stations at different sections of the hatchery. Others have a biosecurity station the staff use without it being an access point. Facilities that process fish already follow strict guidelines for biosecurity and food safety that require controlled access points and comprehensive biosecurity programs above and beyond what is needed for a farm.

c) **Opportunity for Tech Upgrade Implementation to Reduce Potential COVID19 Spread:**

Accessibility controls are especially important to reduce the chance of the COVID19 virus being introduced to a farm from outside the farm bubble. Farm workers who follow all guidelines and workflow changes, stay home, and stay in their bubble are still at risk on being infected by a contractor, visitor or member of the public who comes to the farm. Controlling the flow of people into the facility and forcing them through secure points will allow for tracking and disinfection of contractors, shipping, and visitors. Less people coming onto a farm and less points of possible transmission will further protect farm workers.

d) **Technology Options Available to Industry:**

This technology is not specific to aquaculture and thus there are a wide array of solutions available to the farmer. Fencing to exclude people, gates with intercom systems and key card entry are common at any secure facility and are easily adapted to hatcheries. Key card door locks are available for around $1000.00 CAD per door plus installation and cards, while intercom and automated gate systems are available starting at $20,000.00 CAD plus installation. Biosecurity points are generally renovated, or constructed rooms adapted to biosecurity. These rooms plus materials to create a controlled access point are readily available construction materials, cost depending on size of the room.

e) **Comparable Sites and Operations Using this Technology:**

There is a plethora of good examples of other comparable sites using this technology to control access. Food mills are a good example where a system is in place to direct and control the flow of visitors and shipping vehicles by forcing everyone through the same manned access point. In aquaculture, coastal hatcheries strictly control access because of the risk of vandalism by protestors and the risk of pathogen transmission from the environment. Each commercial hatchery on Vancouver Island is protected by a gate with a key card/intercom system and strict disinfection stations and protocols.

f) **Co-benefits to the Sector:**

Greater access control will protect the safety of the fish stock from external pathogens, protect visitors from wandering into potential hazards, keep out vandals and thieves, and create a system to

direct shipping and visitors through bio-secure access points. Investment in biosecurity rooms will further protect fish by stopping pathogens from entering the facility with staff and visitors.

g) **Effect on Current Local Work Force:**

Each employee will have to be given access to the facility through the system in place and trained on its daily use. Otherwise, there is no specialized training or affect on the work force.

h) **Feasibility rating:** 7.07

Accessibility controls can be a preventative control to keep the virus from entering a facility, but they can be complicated to install, and they offer little to improve efficiency or labour.

8. Humane Harvesting Equipment

a) **Note:** The same humane harvesting equipment used for net net-pens is recommended for hatcheries that slaughter fish. Please see humane harvesting equipment in net-pen section above.

Discussion

Investments made in the net-pen sector will have a large impact on the industry in Ontario because net-pens production dominates the sector. There are more workers concentrated together at net-pen farms than other farms in the sector, particularly when performing tasks that require large amount of physical labour. Net-pen sites, particularly those with the least amount of fish farming technology, are a) at much greater risk of COVID19 spread b) inefficient c) less safe for workers than sites without automation. Any investment that reduces labour would go a long way to limit the spread of COVID19 and improve the efficiency of the sector.

Fish pumps and materials handling are the most feasible options to limit COVID19 spread and increase production for net-pen sites. Fish pumps will decrease the congregation of labourer needed for harvest. Fish pumps are plug and play, needing little infrastructure to be installed as they are portable and maneuverable. Further, fish pumps are a keystone piece of technology that works with other new and developing technologies like counters, graders, and humane harvesting units. Without the fish pump, other pieces of farming equipment cannot be adopted.

The adoption of centralized feed systems is overdue on Ontario net-pen farms, according to those interviewed. A centralized feed system would eliminate much of the labour currently associated with feeding and feed handling. Countless worker hours are used on trips back and forth filling the fish feeders and moving tons of feed around. While less impactful at preventing the spread of COVID19 than a fish pump and having a much higher investment cost, centralized feed systems are the most impactful technology net-pen farmers can adopt to increase efficiency and production long term. Unlike fish pumps and handling equipment, the use of centralized feeders will increase fish size thereby directly increasing fish value at harvest, which increases profitability.

Better materials handling will decrease the labour needed for these common tasks, also decreasing the congregation of labourer need to move tons of harvested fish and feed around the site. There an many solutions to materials handling and technology needed is best identified by the site and their needs. Adopting centralized feeders will eliminate some of the materials handling concern associated with feeding by eliminating the need to take feed to the net-pens.

Land based farms are much more diverse and there is wide variation in what technologies they require. Different facilities have much different needs based on what technologies are already in place.

Technologies to reduce labour at Ontario land-based farms will go the furthest to reduce the spread of COVID19, but the impact of each technology will be specific to conditions on the farm.

Fish pumps are the best option for many farms to reduce congregated labour. Fish pumps are versatile and drop the labour required for many common jobs. Like at net-pen sites, fish pumps are a keystone technology; a gateway technology to operating higher technologies. Counters and graders are used much more frequently at land-based facilities and require a fish pump to work efficiently.

Egg sorters were identified as a tool to prevent the spread of COVID19 because they lower the close quarters labour needed in a particularly cramped and congested space. Though they have a high price an egg sorter will eliminate most of the labourers needed to sort the eggs and make the task much shorter, keeping people out of cramped egg rooms. Despite their high initial cost, egg sorters are a good investment to improve egg husbandry and increase egg production long term.

Automation to eliminate workers is the biggest priority to limit the spread of COVIID19 at Ontario aquaculture farms. Reducing the congregation of labour to perform shoulder to shoulder tasks will protect all workers at the farm from COVID19.

Conclusions:

A COVID19 outbreak at an Ontario fish farm could be devastating for the farm and their stock. By adopting innovative technologies to provide automation, like fish pumps, Ontario farms can limit the spread of the virus and increase their operations long term. Any automation additions to the net-pen sector will have wide ranging affects because net-pens dominate the sector. The increase in production from automation technology will increase the profitability of the sector long term. Fish pumps, materials handling equipment and centralized feeders are the best recommendations for net-pen farmer.

Land-base farms are much more complicated and have much more specific needs. Automation like fish pumps, graders, counters, and egg sorters will allow many operations to further protect their workers from the spread of COVID19 and to expand their egg production without expanding their footprint. Automation technologies are safer for fish and human, and eliminate much fish stress, reduce the risk of dropping fish and diminish the risk of worker injury from performing demanding repetitive physical tasks.

Appendix

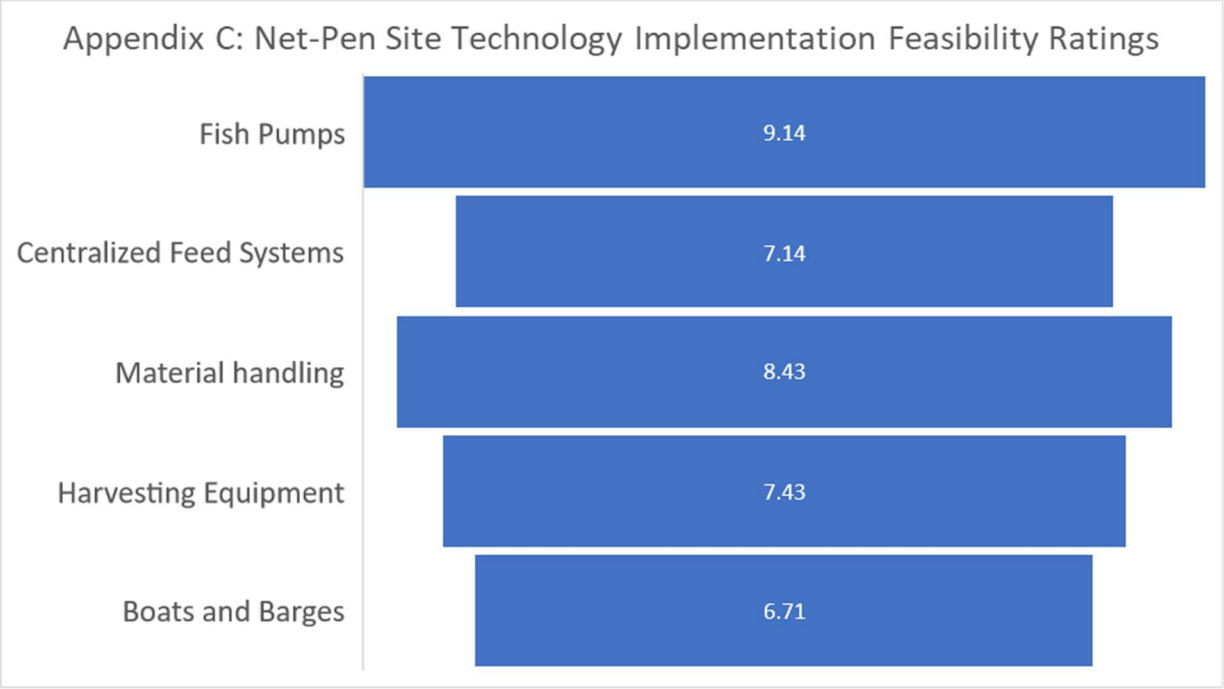
Appendix A- Technology Feasibility Rating Table, Ontario Aquaculture Net-pen Farms

Technology	Estimated Cost ($CAD)	Effectiveness to Prevent COVID19 Spread (1-10)	Cost Rating	Impact on Efficiency Longterm	Ease of Installation	Installation Time	Labour Reduction	Labour Specialization Needs	Overall Feasibility
Fish Pumps	120,000-160,000	9	8	9	10	10	8	10	9.14
Centralized Feed Systems	200,000-2.0 mil per site	9	5	10	5	5	10	6	7.14
Material handling	1500-50,000	9	9	9	8	8	8	8	8.43
Harvesting Equipment	175,000-550,000	10	6	7	7	7	9	6	7.43
Boats and Barges	10,000-1.0 mil	7	6	6	9	8	1	10	6.71

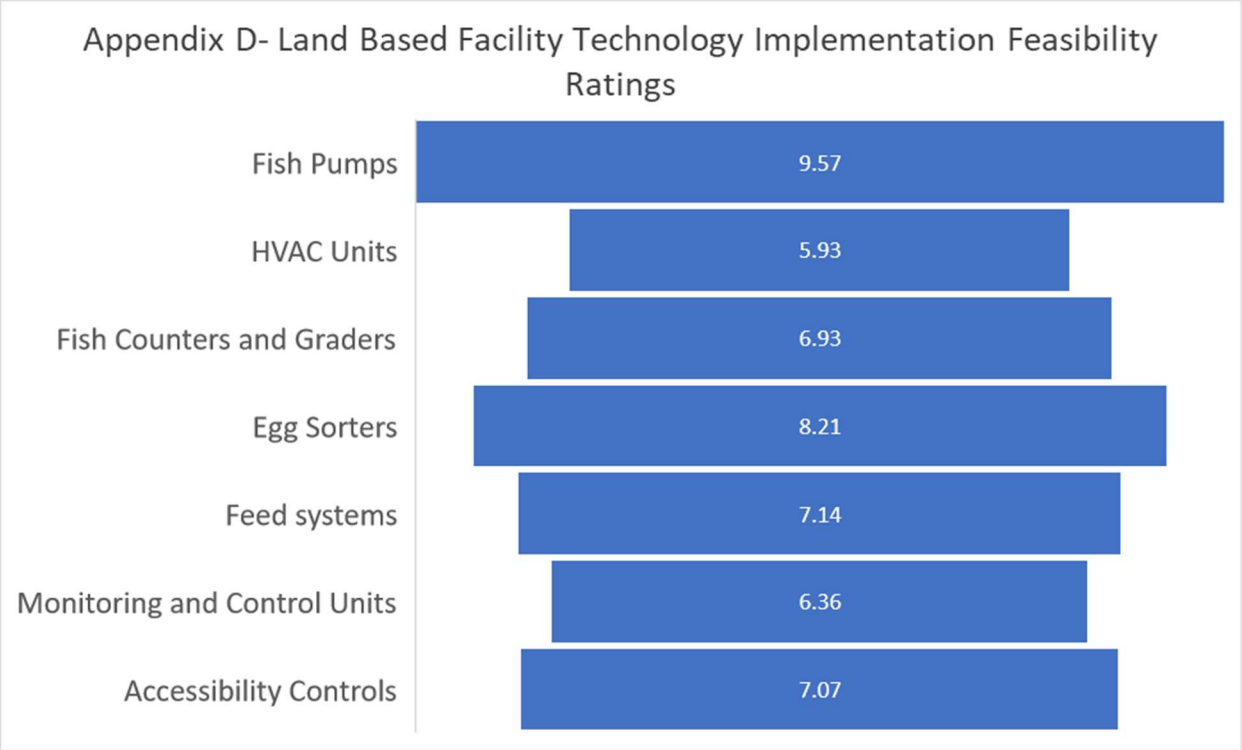
Appendix B- Technology Feasibility Rating Table, Ontario Land Based Aquaculture Farms

Technology	Estimated Cost ($CAD)	Effectiveness to Prevent COVID19 Spread (1-10)	Cost Rating	Co-benefit to Sector	Ease of Installation	Installation Time	Labour Reduction	Labour Specialization Needs	Overall Feasibility
Fish Pumps	20,000.00-160,000.00	9	9	10	10	10	9	10	9.57
HVAC	5,000.00-400,000.00	9	6.5	5	5	5	1	10	5.93
Fish Counters and Graders	8,000.00-350,000.00	5	7	8	9	8	4	7.5	6.93
Egg Sorters	90,000.00-150,000.00	8	6	8	9	10	8	8.5	8.21
Centralized and Automated Feed systems	Centralized 700,000-2.0 million Automated 450.00 - 10,000.00 per tank	6	6	9	7.5	6	8	7.5	7.14
Monitoring and Control Units	150,000.00+	4	6.5	10	6	6	6	6	6.36
Accessibility Controls	5,000.00-50,000.00	9	10	7.5	6	6	1	10	7.07

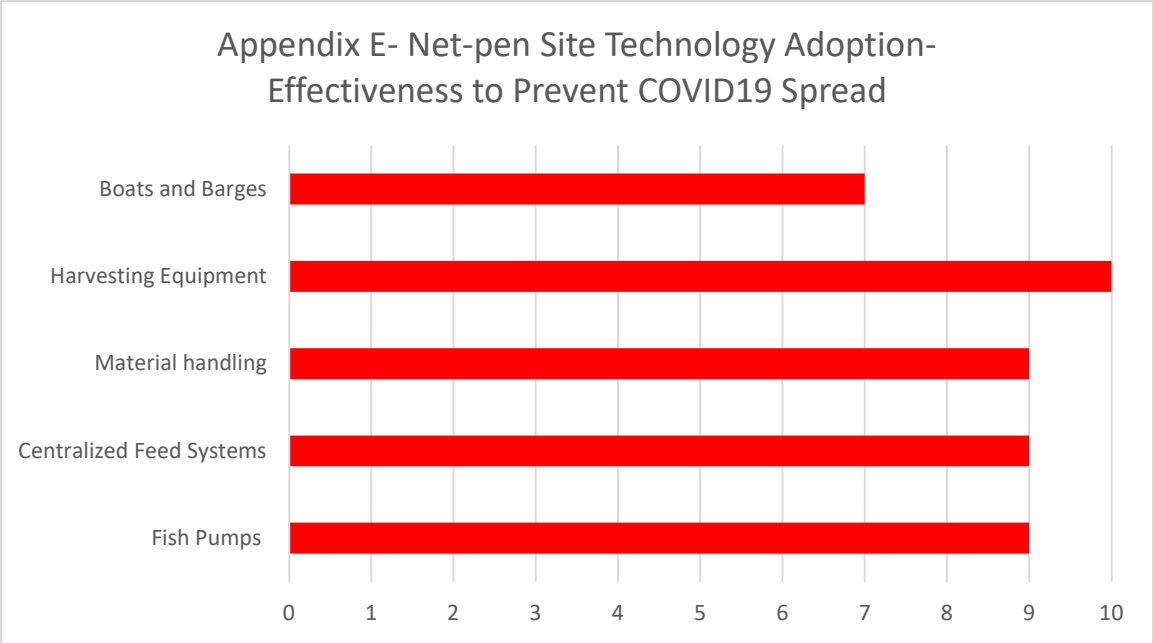
Appendix C: Net-pen Site Technology Implementation Feasibility Ratings



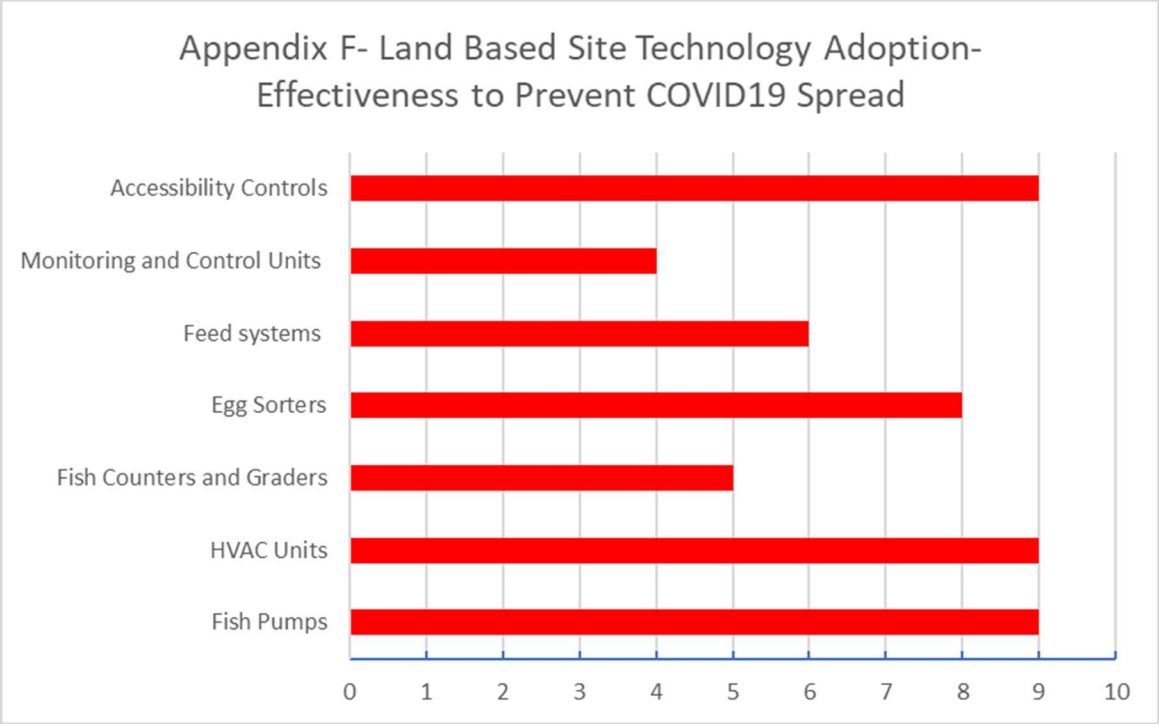
Appendix D- Land Based Facility Technology Implementation Feasibility Ratings



Appendix E- Net-pen Site Technology Adoption- Effectiveness to Prevent COVID19 Spread



Appendix F – Land Based Site Technology Adoption- Effectiveness to Prevent COVID19 Spread



Appendix G – List of Participants

Industry Members Interviewed

- Susan Cole, Owner/Operator, Cole Munro Foods
- Jason Hughson, Farming Manager, Wabano Channel Farms
- Clarke Reick, Owner/Operator, Lyndon Farms
- Marcia Chaisson, Manager, Alma Research Centre, University of Guelph
- Steve Naylor, Senior Regional Aquaculture Officer, Department of Fisheries and Oceans
- Nathan Kanasawe, Manager, Buzwah Fisheries
- Roger Bushey, Manager, Sandplains Aqua
- Arlen Taylor, Owner/Operator, Cedar Crest Farms/Springhill Fish
- Kana Upton, Farming Manager, Aquanet-pen
- Sean Pressey, Production/Operation Manager, Planet Shrimp
- Mike McQuire- Aquaculture Specialist, OMAFRA
- Terry Drost, Owner/Operator, 4 Links Marketing
- Ken Duquette, Manager, Manitoulin Trout Farms Coldwater
- Manny Resendes, Director of Operations, John O Foods

Other Aquaculture Resources Contacted

- Scott Stangret, Net-pen Site Manager, Cermaq Canada, Campbell River BC
- Lance Page, Manager, Dalrympyl Hatchery, Mowi Canada West, Sayward BC
- Gatchel Griffin, Saltwater Training Compliance Officer, Cooke Aquaculture, St. Andrews NB
- Donald Orton, Technician, Big Tree Creek Hatchery, Mowi Canada West, Sayward BC
- Jon Carter, Aquaculture Professor, Fleming College, Lindsay ON
- Richard Moccia, Director of Aquaculture Centre, University of Guelph, Guelph ON

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