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Aquaculture Feasibility Assessment for the Community Economic Development Commission of Thunder Bay, Ontario

Submitted to:

THUNDER BAY
CEDC
COMMUNITY ECONOMIC DEVELOPMENT COMMISSION

Prepared by:

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High Impact Project Based Consulting

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EXECUTIVE SUMMARY

The Community Economic Development Commission of Thunder Bay (CEDC)[1] has been exploring opportunities to enhance the supply of sustainably produced, fresh local food in the city and surrounding region. On option being explored is aquaculture, the farming of fish and seafood. This review considers the feasibility to develop aquaculture based on the existing regulatory framework, the available biophysical resources, and the local, regional and international market demand. Potential next steps to successfully develop an aquaculture sector in the region are also discussed

Aquaculture is the fastest-growing food production sector in the world. Grounded in science and technology, this market-driven sector has emerged to provide consumers with the taste, value, and convenience in seafood products similar to that which they have come to expect from other commodities. Moreover, at a time when global fisheries can no longer be depended upon to provide stable employment in coastal communities, aquaculture generates safe, high-quality seafood for consumers.

Commercial aquaculture in Canada generates more than $1.39 billion in farm-gate revenues and accounts for 16% of Canada's total seafood production (+/- 200 k tonnes annually).[2] Today, most of the production is derived from four primary species: Atlantic salmon, Rainbow Trout, Mussels and Oysters.

Potential species for cultivation were reviewed and a three species were short-listed and further evaluated to identify a species that could be commercially cultured in the Thunder Bay region. Rainbow trout scored highest; largely owing to the long-standing success associated with the commercial cultivation of the species in Canada. Trout is widely recognized as a highly desirable fish by most North American consumers. While *per capita* consumption of seafood, in general, has been increasing over the past decade (driven by population growth and favourable demographics – an ageing population and increased affluence), trout consumption rates have remained relatively stable – due to the shortage of supplies. The North American market for rainbow trout is domestic supply-limited.

Both land-based and lake-based opportunities could be further explored as the preliminary evaluations indicate that the environmental factors are favourable for development. An initial assessment of the suitability of waters along the north shore of Lake Superior for the potential development of net pen aquaculture was conducted. The review examined the shoreline from Copper Island west of Schreiber to Pie Island south of Thunder Bay, an area of approximately 180 km. This review identified three potential areas that may be suitable for the establishment of net-pen aquaculture sites.

A production plan is presented as a means of illustrating the scope of the investment required for an annual production of 250 MT's. The land-based system is based on high-intensity RAS technology and the culture of rainbow trout. The lake-based scenario uses a net pen system using steel cages as per the current industry in Lake Huron.

[1] Adapted from CEDC RFP document– Thunder Bay Aquaculture Feasibility Study. 28 August 2020.6pp
[2] http://www.aquaculture.ca/

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1.0 OVERVIEW OF THE AQUACULTURE SECTOR

Aquaculture is the fastest-growing food production sector in the world. Grounded in science and technology, this market-driven sector has emerged to provide consumers with the taste, value, and convenience in seafood products similar to that which they have come to expect from other commodities. Moreover, at a time when global fisheries can no longer be depended upon to provide stable employment in coastal communities, aquaculture generates safe, high-quality seafood for consumers.

Today, 50%[3] of all fish and seafood for human consumption (this excludes fish meals and oils) is now sourced from aquaculture. In 2013, global aquaculture output surpassed beef production and, by 2030, the United Nations Food & Agriculture Organization predicts that aquaculture's contribution to the global seafood supply will exceed 62%. This rapid growth reflects the extraordinary potential in the industry and the inability to harvest fisheries to increase output suggests that aquaculture will remain competitive well into the future.

1.1 International Aquaculture Sector

According to the Food and Agriculture Organization (FAO) publication of the State of the World Fisheries and Aquaculture (2018), the capture fisheries from around the world have been yielding approximately 90 million tonnes of annual harvest, with an additional +80 Million tonnes being derived from aquaculture.

Table 1 World Fisheries and Aquaculture Production[4]

World Fisheries and Aquaculture Production (Million tonnes)						
Capture Fisheries	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Inland	10.7	11.2	11.2	11.3	11.4	11.6
Marine	81.5	78.4	79.4	79.9	81.2	79.3
Total Capture	92.2	89.6	90.6	91.2	92.6	90.9
Aquaculture						
Inland	38.6	42.0	44.8	46.9	48.6	51.4
Marine	23.2	24.4	25.4	26.8	27.5	28.6
Total Aquaculture	61.8	66.4	70.2	73.7	76.1	80.0
Total	154	156	160.8	164.9	168.7	170.9
Human Consuption	130.0	136.4	140.1	144.8	148.4	151.2
Non food uses	24.0	19.6	20.7	20.1	20.3	19.7
Population (billions)	7.0	7.1	7.2	7.3	7.3	7.4
Per Capita Consumption (kg)	18.6	19.2	19.5	19.8	20.3	20.4

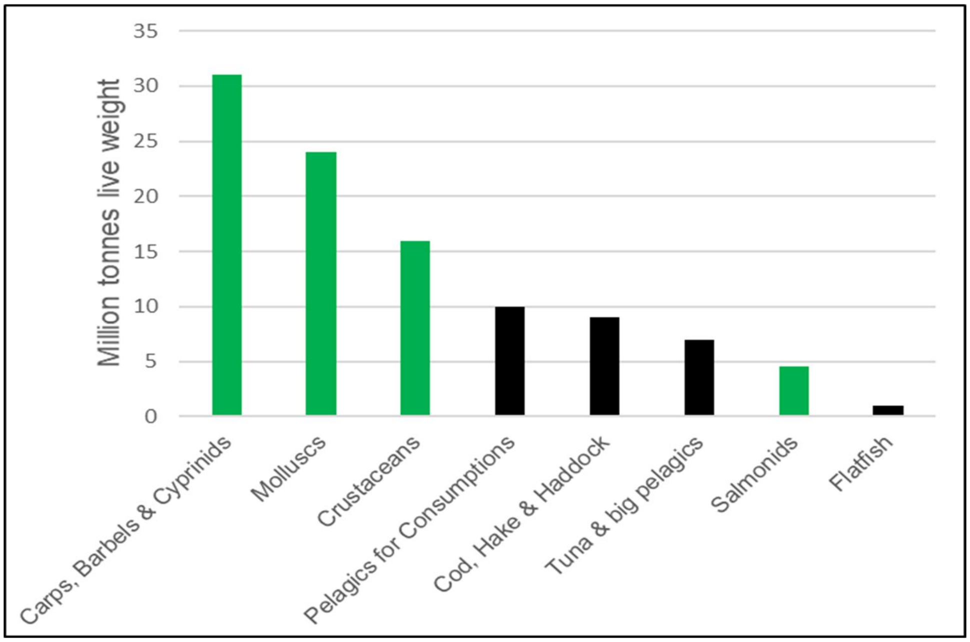
[3] Brugère, C. & N. Ridler (2004). Global Aquaculture Outlook in the Next Decades: An Analysis of National Aquaculture Production Forecasts to 2030.

[4] Adapted from FAO 2018. The State of World Fisheries and Aquaculture. Meeting the Sustainable Development Goals

MOWI[5], currently the world's largest aquaculture company, publishes an annual summary of the state of aquaculture called the Salmon Industry Handbook. They provide a breakdown of the major farmed species (Table 2). The farmed species are illustrated in green, wild-caught in black

As the fastest growing animal-based food-producing sector, aquaculture is a major contributor to the growth in the consumption per capita of seafood. This output growth outpaces population growth. Great progress in breeding technology, system design and feed technology in the second half of the twentieth century has enabled the expansion of commercially viable aquaculture across species and in volume. In 2013-15, China alone produces 62% of global aquaculture output, while Asia accounts for 88%.

Table 2 World Fisheries and Aquaculture Production Volumes – Selected Seafood Species[6]

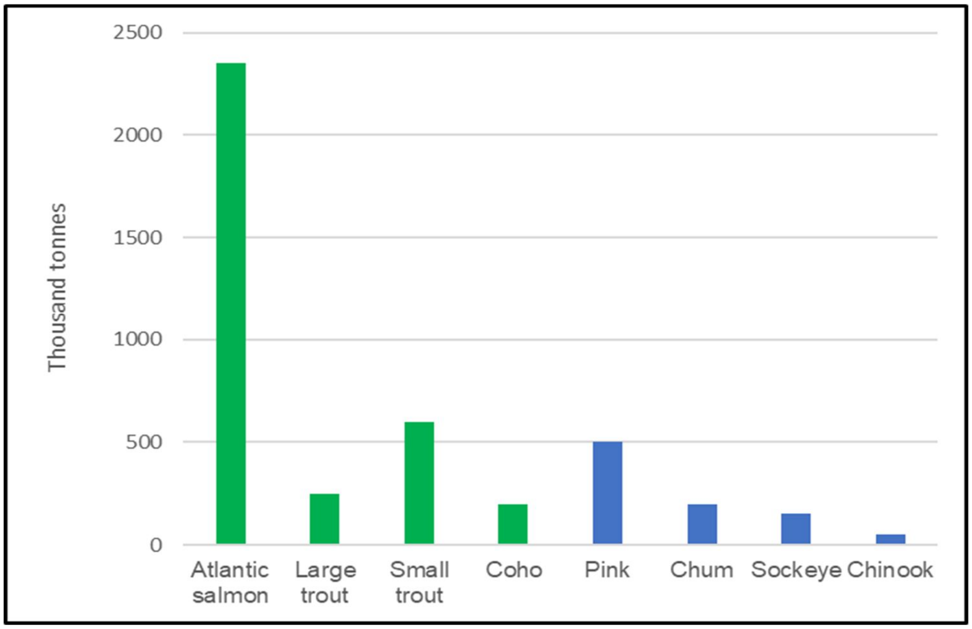


The World Bank Group (WBG) developed a scenario analysis in their report Fish to 2030 (2013) predicting that aquaculture will continue to fill the supply-demand gap. Aquaculture currently accounts for over 80 million tonnes (live weight) destined for direct human food consumption[7]

Although many other farmed species produce greater harvest volumes, the farmed salmonids are the most important economic species in aquaculture generating an estimated $ 14.7 B (USD) per annum. A breakdown of the major farmed salmonids is presented in Table 3[8] The farmed species are illustrated in green, wild-caught in blue.

5 https://mowi.com
6 Adapted from Salmon Industry Handbook 2020. https://mowi.com
7 World Bank (2013) Fish to 2030,
8 Adapted from Salmon Industry Handbook 2020. https://mowi.com

Table 3 Aquaculture Production Volumes – Major Salmonids Species



Certain biological parameters are required to allow the efficient production of aquaculture species. A key condition for areas considered suitable for salmonid farming is a water temperature range between zero and 20°C. Salmonids also require a certain amount of water current to flow through the farm. The current in land-based tanks or flowing through a net pen system must, however, be below a certain velocity to allow the fish to move freely.

Land-based salmon farming (full-cycle) has attracted increased investments in the past years. To date, only limited volumes of production have been harvested on land, however, this could change going forward as new technologies continue to mature.

1.2 Canadian Aquaculture Sector

Commercial aquaculture in Canada generates more than $1.39 billion in farm-gate revenues and accounts for 16% of Canada's total seafood production (+/- 200 k tonnes annually).[9] Today, most of the production is derived from four primary species: Atlantic salmon, Rainbow Trout, Mussels and Oysters.

Aquaculture is also having a significant impact on consumption. In North America, farm-raised species now account for more than 43 percent of total seafood consumption – and more than 50% of all non-canned products. By producing a consistent, quality product on a year-round basis, the aquaculture sector can provide consumers with superior convenience and value. Tables 4 & 5 outlines the production data for Aquaculture in Canada.

[9] http://www.aquaculture.ca/

Table 4 Canadian Aquaculture Industry by the Numbers

PRODUCTION	Salmon	Trout	Mussels	Oysters	Other	Total
Aquaculture Production Volume: (annual tonı	122,300	7,000	23,000	25,800	13,316	191,416
Aquaculture Production Value: $1.39 billion						
Aquaculture accounts for 16% of Canada's total seafood production						
Aquaculture accounts for over 33% of Canada's total seafood value						
Aquaculture generates $5.4 Billion in economic activity in Canada						
Aquaculture generates $2.2 Billion in GDP						

Table 5 Canadian Aquaculture Industry – Largest Producers

Largest Producers	Salmon	Trout	Mussels	Oysters	Other Species	
Cemarq Canada	BC					
Cooke Aquaculture	NB,NS,NL					
Creative Salmon	BC					
Grieg Seafood BC Ltd	BC,NL					
MOWI Canada	BC,NL,NB					
Icy Waters Ltd					YT	Arctic Charr
Cole-Munro (Manitoulin Trout Farms)		ON				
Ocean Trout Canada		NS,NL,NB				
Varia - Land based systems		QC,ON,NS				
Wild West Steelhead		SK				
Atlantic Aqua Farms Ltd			PEI		PEI	Quahogs
Badger Bay Mussel Farms Ltd			NL			
Confederation Cove			PEI			
Coastal Shellfish Corp				BC		
Fanny Bay Oysters				BC	BC	Clams
K'AWAT'SI Shellfish Company				BC	BC	Scallops
Mac's Oysters Ltd				BC	BC	Clams
Maison Beausoleil				NB		
Cascadia Seaweed					BC	Seaweed
Golden Eagle Sable Fish					BC	Sable Fish
Halibut PEI					PEI	Halibut
Magellan Aqua Farms Ltd					NB	Scallops
Northern Devine Aquaframs Ltd					BC	Sturgeon

Freshwater aquaculture is a highly productive and sustainable use of aquatic resources with considerable potential for growth throughout all regions of Canada[10]. Many rural communities have bio-physical resources and socio-economic interests to participate in freshwater aquaculture development. The land-based production of freshwater salmonid species is one potential means to fulfil this potential[11].

[10] Stechey, D, Albright, L, Foss, D, Gilbert, E, Lareau, S, Maheu, J, McNaughton, M, Meeker, M, Robertson, W.D. (2007). Status and Outlook for Freshwater Aquaculture in Canada: Regional Perspectives. Aquaculture Canada 2007 - Proceedings of Contributed Papers, AAC Special Publ. No. 13.

[11] Stechey, D. and E. Gilbert (2004). Aquaculture as an Agricultural Diversification Strategy. Proceedings of the Canadian Freshwater Aquaculture Symposium, Quebec City, QC. AAC Special Publ. No. 11-159-168.

1.3 Aquaculture in Ontario

Since the 1960s, the Ontario aquaculture sector has been the leading producer of freshwater farmed fish in Canada. Ontario farms produced more than 7,000 tonnes of rainbow trout having a farm-gate value above $30 million Can. Lake-based, net pen production accounts for 85% of the total production. Ontario's aquaculture industry entered a period of gradual expansion in production volumes beginning in 2012[12]. The capacity of each aquaculture is site-specific and largely based on the carrying capacity of the environment, as determined by the regulatory agencies.

The net-pen culture industry is mainly located in Lake Huron, with most operations centred in the North Channel area near Manitoulin Island. Today, seven companies operate 12 net-pen culture sites in Lake Huron. Four of the companies and seven of the sites are Indigenous-owned. As a non-extractive, renewable agri-food sector, aquaculture provides considerable benefits to all Ontarians. The industry offers strategic job creation, particularly in rural and coastal communities, and it provides processors with a dependable, year-round supply of products. Aquaculture generates new employment opportunities in production, processing and the many supplies and services ventures that support the industry.

The net-pen ventures purchase fingerlings (juvenile fish) from land-based producers in southern Ontario, stock them into the net pens and rear them to market size in 9 to 15 months. Presently, most fingerings are produced in flow-through land-based facilities that use surface water or groundwater supplies. The cold and seasonally variable water temperatures make it difficult to consistently produce fish of the size that the net pen producers prefer at the times of the year that they require them.

The current demand for rainbow trout fingerlings in Ontario is estimated to be around 6.5 million fish per year. These fingerlings are presently being supplied mainly by six primary fingerling producers. Other smaller producers also exist.

Presently, there are several initiatives underway to expand the Ontario rainbow trout industry. To attain increased production, the demand for fingerlings will need to expand by approximately several million fish per year. Providing fingerlings of the right size and at the right time of year for stocking will enable net-pen ventures to maximize productivity. This approach can be best achieved using recirculating aquaculture technologies (RAS).

[12] Moccia, R.D and D.J Bevan (2017). Aquastats – Ontario Aquaculture Production in 2016

1.4 Regulatory Framework for Aquaculture Development in Ontario

"*Legislation affecting commercial aquaculture in Ontario is principally concerned with the orderly development of the industry, management of the environment and its indigenous organisms, the safety of fish products and the protection of consumers. This requires a balance between allowing new and diverse forms of farming activity while preventing, or at least managing, the effects of these activities. The laws affecting aquaculture involve federal, provincial and municipal governments in a complex and dynamic legislative network*.[13]"

Table 6 outlines the primary areas of jurisdiction that govern Aquaculture in Canada. The provinces of British Columbia and Prince Edward Island have additional involvement from Federal Agencies.

In Ontario, the key provincial government agencies involved in the regulation and administration of aquaculture are the Ontario Ministry of Natural Resources and Forestry, the Ontario Ministry of the Environment and Climate Change, the local Conservation Authority, the Ontario Ministry of Municipal Affairs and Housing and the local Municipality.

The key federal government agencies are Fisheries and Oceans Canada, Transport Canada, Canadian Food Inspection Agency, Health Canada and Environment Canada. Also, several provincial and federal government agencies that regulate most business ventures are involved in aquaculture regulation.

Table 6 Canadian Aquaculture Industry Regulatory Overview[14]

Aquaculture - Jointly Managed by Federal, Provincial & Territorial Governments			
	British Columbia	Rest Of Canada	Prince Edward Island
Site Approvals - determining where a farm can be located	**Shared**	**Provincial**	**Shared**
Land Management - overseeing the land (seabed) where a is located	**Provincial**	**Provincial**	**Federal**
Day to Day Operations & Oversight -monitoring of farm activities	**Federal**	**Provincial**	**Federal**
Introductions & Transfers - manageing planned movement of live eggs and fish	**Shared**	**Shared**	**Shared**
Drugs & Pesticide Approvals - determining which drugs and pesticides asre approved for use	**Shared**	**Shared**	**Shared**
Food Safety - monitoring and ensuring safety and quality of fish harvested and sold in Canada and International markets	**Federal**	**Federal**	**Federal**

[13] https://ontarioseafoodfarmers.ca/wp-content/uploads/2018/06/2018-Aqua-Legislation-Factsheet-
[14] Adapted from www.dfo-mpo.gc.ca/aquaculture/publications

While the Federal Government is responsible for fisheries management in Canada, the Ontario Fishery Regulations confer the authority for administering certain aspects of fish and fisheries management to the Ontario Ministry of Natural Resources and Forestry (MNRF). MNRF also administers the Fish and Wildlife Conservation Act of Ontario (with its associated regulations) which provides for the management, perpetuation and rehabilitation of all Ontario's fish and wildlife resources.

An Aquaculture Licence in Ontario permits the licence holder to culture, purchase, sell and transport the named species specified in the licence. The granting of an Aquaculture Licence depends upon MNRF specialists who assess the potential ecological impacts of the proposed fish farm. The licence is valid for a fixed length of time as specified in the licence. An aquaculture licence may be renewable and transferable, providing the licence conditions are complied with. The net-pen culture activities on public lands (i.e. lakes) require the monitoring and maintenance of the water and sediment quality as specified on the Aquaculture Licence.

First Nations Perspective

Protection of water is fundamental to all aspects of Indigenous culture – in Canada and around the world. Indigenous peoples regard water as a living thing, a spiritual entity with life-giving forces. This necessitates certain duties and responsibilities to ensure that it is respected, protected and nurtured[15]. Water stewardship is a key aspect of First Nations' relationships with the environment. This is the basis of Anishinaabe nibi governance, a decision-making process through which water is managed[16].

First Nations communities in Ontario have been developing a governance framework – the *Giigoonh Chi-Naaknigewin* – to issue licences, leases, permits, rules and requirements for establishing aquaculture operations on First Nations' traditional lands and waters, and empowering First Nations to manage their aquatic and terrestrial resources. Development and implementation of the *Giigoonh Chi-Naaknigewin* will ensure that all aquaculture ventures in Ontario, including those operated by Indigenous and non-Indigenous persons or organizations, are properly licenced and adhere to the principles of sustainable development. The *Giigoonh Chi-Naaknigewin* is being developed based on the existing guidelines and procedures for siting and licensing aquaculture operations. [For additional information, contact Nick Huber, Waubetek Business Development Corporation (519) 476-0630)]

In most jurisdictions, licensing and permitting for aquaculture development prescribes a structured application process. Completed applications are vetted through a formal review process. Upon approval, permissions are granted and fees are imposed in exchange for privileged access to resources. On-going monitoring and routine reporting are required throughout the operational phase of the aquaculture venture. Compliance standards and enforcement tools are applied to maintain orderly development and operations.

[15] Szach, Natasha J. (2013). Keepers of the Water: Exploring Anishinaabe and Métis Women's Knowledge of Water and Participation in Water Governance in Kenora, Ontario. Master of Natural Resources Thesis, University of Manitoba. 175 p.

[16] Chiblow, Susan (2019). Indigenous Women's Nibi Giikendaaswin (Water Knowledge). Water 2019, 11, 209; doi:10.3390/w11020209. www.mdpi.com/journal/water

Provincial Aquaculture Legislation

The Aquaculture Centre in the Department of Animal Biosciences at the University of Guelph[17] developed a fact sheet that provides an overview of Ontario aquaculture legislation, the applicable Acts, Regulations, and important agencies. The information in this section is largely derived from this fact sheet.

Table 7 provides an overview of the Provincial agencies involved in governing Aquaculture activities in Ontario. A Licence to Collect Fish from Ontario Waters is required before wild fish or their gametes are taken from Ontario public waters. The issuing of this licence is based on a variety of criteria including conservation needs, aboriginal or treaty rights and the needs of all other resource users, including aquaculture.

Table 7 Provincial Agencies Governing Aquaculture Activities[18]

Provincial Government Agencies	Summary of Principle
Ontario Ministry of Natural Resources and Forestry	
Fish and Wildlife Conservation Act + Ontario Regulation 664/98	*Provides management, perpetuation and rehabilitation of wildlife*
Lakes and Rivers Improvement Act	*Ensures alterations to water flow do not pose hazard*
The Conservation Authorities Act	*Preservation of habitat within established flood plains*
Beds of Navigable Waters Act	*Lake bed lease required for net pen culture operations*
Public Lands Act	*Controlled use of public land and net pen culture areas*
Provincial Parks and Conservation Reserves Act	*Controlled use of public land and net pen culture areas*
Aggregate Resources Act	*Regulates aggreagte removal from water courses*
Endangered Species Act	*Restricts activities that may endanger a species*
Ontario Ministry of the Environment and Climate Change	
Ontario Water Resources Act	*Management of surface and ground water quality and quantity*
The Environmental Protection Act	*Provides protection and conservation of the natural resources*
Pesticides Act	*Controls the availability and use of pesticides*
Environmental Assessment Act	*Allows environmental assessments to be carried out*
Conservation Authority	
The Conservation Authorities Act	*Controls development within flood plains (see OMNRF)*
Ontario Ministry of Municipal Affairs and Housing and Local Municipality	
The Planning Act	*Allows for orderly planning and development of land use*
Provincial Municipal Act	*Bylaws etsablished by local government to regulate land use, etc.*
The Niagra Escarpment Planning & Development Act	*Additional controls for development in this area*
Ontario Ministry of Agriculture, Food and Rural Affairs	
The Drainage Act	*Controal darinage of land, including the discharge of surface waters*
The Veterinarians Act	*Regulates drug use*
Fish Inspection Act	*Inspection of products to ensure safety and quality*
Ontario Ministry of Labour	
Occupational Health and Safety Act	*Protects workers and health and safety hazards*
Ontario Ministry of Transportation	
Highways Act	*Regulates well structures next to highways*
Ontario Ministry of Consumer & Commercial Relations	
	Company registration and incorporation

[17] http://animalbiosciences.uoguelph.ca/aquacentre/files/about-ontario-aquaculture/Aqua%20Legislation%202018-Factsheet.pdf

[18] Adapted from https://ontarioseafoodfarmers.ca/wp-content/uploads/2018/06/2018-Aqua-Legislation-Factsheet-

In Ontario, the law respecting watercourses is based on the maxim of Common Law "*Aqua currit et debet currere*", which translates as "water flows naturally and should be permitted to thus flow". MNRF is responsible for administering the Lakes and Rivers Improvement Act which requires approvals before construction of any works in or near water.

MNRF also administers the Beds of Navigable Waters Act and the Public Lands Act, which requires a Land Use Permit or Lease Permit for cage (or net-pen) culture operations, and the Provincial Parks and Conservation Reserves Act that excludes aquaculture from these areas. Under the Environmental Bill of Rights, MNRF is required to provide notice on the Environmental Registry of any net-pen aquaculture application.

In addition to MNRF's interest in the use of lakes and rivers, the Ontario Ministry of the Environment and Climate Change (MOECC) has a statutory mandate governing the supervision and management of surface and groundwater resources throughout the province.

The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and the local Municipality administer The Drainage Act. This Act can affect aquaculture facilities that intend to discharge effluent into a municipal drainage system. The Nutrient Management Act requires an approved Nutrient Management Strategy for all farms that generate more than five nutrient units. The determination of nutrient units that pertain to aquaculture are being finalized.

OMAFRA is also responsible for Ontario's Veterinarians Act, though certain aspects (but not all) of the diagnosis and treatment of fish are exempt from the provincial legislation. Drug prescription is only permitted by a qualified and registered veterinarian (see Federal Government Agencies, Health Canada).

Fish products sold within Ontario may be subject to the Fish Inspection Act. As part of the Fish Interim Audit Program, OMAFRA audits non-federally registered fish processors. The conditions in an aquaculture license prohibit or restrict the introduction of invasive species as listed in regulations. As such, an aquaculture application will not be approved for any regulated species. The licence allows the sale of fish species specified in the licence. Processed product sold at the "farm gate" normally requires no additional permits. However, the sale of smoked fish products and other high-risk ready-to-eat fish products, regardless of the point of sale, may be regulated by Health Canada and the local Health Department. When fish and fish products are moved between provinces or exported from Canada, they are subject to federal jurisdiction (see Federal Government Agencies, Agriculture and Agri-Food Canada, Canadian Food Inspection Agency).

Federal Aquaculture Legislation

Fisheries and Oceans Canada (DFO) is the lead federal department with regulatory responsibility for aquaculture. The main legislation includes the Fisheries Act and the Species at Risk Act (jointly administered with Environment Canada). Under the Fisheries Act, DFO's Regional Management Office ensures that all facilities comply with the Aquaculture Activities Regulations.

This includes:

a) land-based operations discharging into fish-bearing waters;
b) marine and freshwater cage finfish operations; and
c) additional documentation of drug and pesticide use and, where applicable, sediment biological oxygen demand.

The Fisheries Act restricts any works that may result in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery. The Species at Risk Act (SARA) is to prevent listed species from becoming extinct or extirpated and includes a wide variety of measures that can be triggered by an aquaculture licence application (especially for net-pen culture operations). The federal SARA and the provincial Endangered Species Act are complementary in their action, and adherence to both is required.

The coordination of federal, provincial and territorial activities is assisted by the Canadian Council of Fisheries and Aquaculture Ministers and its Strategic Management Committee on Aquaculture (CCFAM). The CCFAM oversees the following: Aquaculture Development Strategy; National Aquaculture Strategic Action Plan and various International collaborations including United Nations (e.g. Canada's Organic Aquaculture Standard) and the Food and Agriculture Organisation (e.g. Technical Guidelines in Aquaculture Certification, Committee of Fisheries, sub-committee aquaculture).

The Canadian Food Inspection Agency (CFIA) administers several acts with their supporting regulations that may apply to or affect an aquaculture business: the Health of Animals Act under which the National Aquatic Animal Health Program and import and registration of fish vaccines and diagnostic kits are regulated; the Feeds Act under which fish feeds and feed additives are regulated; all fish and fish products that are marketed and subsequently transported between provinces or exported from Canada must be processed under the Fish Inspection Act in a federally registered fish and seafood processing plant; the Fertilizers Act under which fertilizers, including fertilizers made from fish, and soil supplements are regulated; and the Canada Agricultural Products Act, for example, the Organic Products Regulations.

The Navigation Protection Act is administered by Transport Canada and the Navigation Protection Program administers and enforces the NPA. The Navigation Protection Program reviews and authorizes the placement or construction of works in any navigable waterway in Canada and is of concern to those considering the use of cages in the Great Lakes or other open water bodies.

Table 8 Federal Agencies Governing Aquaculture Activities[19]

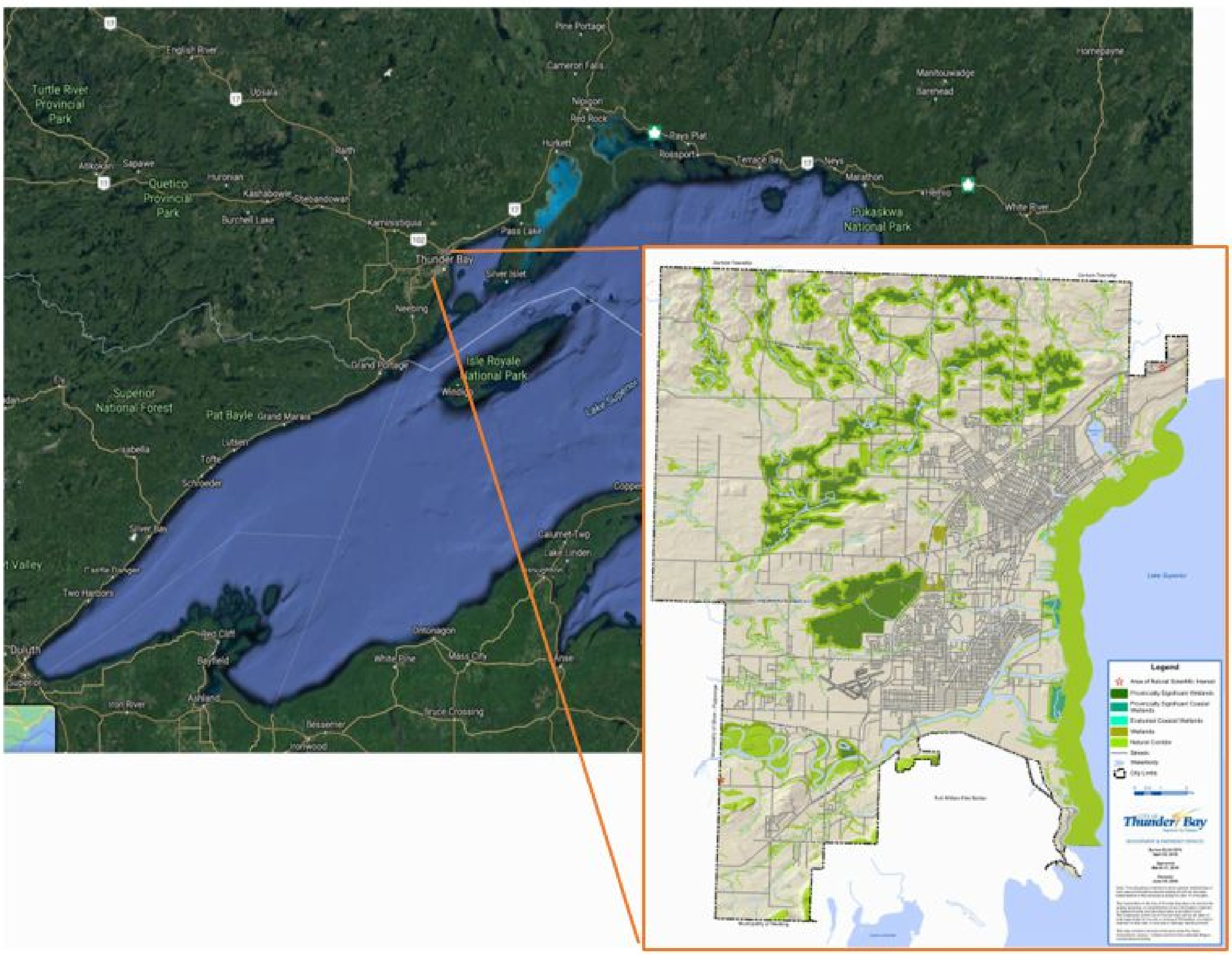
Federal Government Agencies	Summary of Principle
Fisheries & Ocean Canada	
Fisheries Act of Canada	*Provides protection of fisheries and tehir habitat, import/export of fish*
+ Aquaculture Activities Regulations	*Provides mecahnism for regulatory control of Aquaculture*
+ Fish Health Protection Regulations	*Regulates movement of fish species throughout Canada*
+ Ontario Fisheries Regulations	
Species at Risk Act	*Protection of Fisheries, habitat and species at risk*
Canadian Food Inspection Agency	
Health of Animals Act	*Import and registration of biologics and fish vaccines*
	National Aquactic Animal Health Program oversite
Feeds Act	*Regulation of feed ingredients, quality and drugs in feeds*
Fish Inspection Act & Regulations	*Inspection of products for export. Ensures safety and quality*
Safe Food for Canadians Act	*Inspects processing plants*
Health Canada and Pest Management Regulatory Agency	
Food and Drug Act	*Approval of drugs used in animals,including fish and smoked fish products*
Pest Control Products Act	*Registration of pesticides*
Environment Canada	
Canadian Environmental Assessment Act	*Integrates enviornmental factors into the planning process*
Canadian Environmental Protection Act	*Provides protection and conservation of the natural environment*
Migartory Birds Convention Act	*Protection for certain species of birds*
Species at Risk Act	*Protection of wildlife species at risk, including fish*
Transport Canada	
Canada Shipping Act	*Regulates vessel requirements and sfery*
Navigation Protection Act	*Approval of structures placed in navigable waters*
Canada Customs and Revenue Agency	
Goods and Service Act	*Goods and Service Tax and Harmonized Sales Tax*
Government of Canada	
Standards Council of Canada	*Organic Aquaculture Standards*

[19] Adapted from https://ontarioseafoodfarmers.ca/wp-content/uploads/2018/06/2018-Aqua-Legislation-Factsheet-

2.0 AQUACULTURE IN THE THUNDER BAY REGION

The Community Economic Development Commission of Thunder Bay (CEDC)[20] has been exploring the idea of the sustainability of Thunder Bay and the neighbouring community's supply of fresh, locally produced food. One approach to achieving this goal is to investigate the feasibility to develop any form of aquaculture based on the existing regulatory framework, local resources, market demand locally, regionally and internationally, and what next steps would be required to successfully develop an aquaculture sector.

Figure 1: Map of the CEDC Area[21] – Thunder Bay, Ontario (adapted from Google Maps)



20 Adapted from CEDC RFP document– Thunder Bay Aquaculture Feasibility Study. 28 August 2020.6pp

21 CEDC - City of Thunder Bay

2.1 Potential Species for Aquaculture Development

Commercial finfish aquaculture in Canada is focused principally on piscivorous finfish (salmon and trout) species. The selection of a particular species for aquaculture, however, requires a detailed understanding of the species' life history. General physiology, including nutrition, reproduction and growth rate, genetics, behaviour and hardiness are key factors that influence the potential for successful commercial cultivation. In selecting a species for commercial production, it is also necessary to consider the interaction of the species with its living and non-living environment to ascertain the proper design of a culture system. Due to the existence of federal and provincial introductions and transfers policies, the potential to culture exotic (versus local) species must also be assessed. Finally, it will be important to understand the market and to forecast the demand for the various species to fully evaluate the potential of each candidate species.

The Province of Ontario has proclaimed a regulation to manage the species of fish and shellfish that are permissible for commercial culture in the province (Table 9).

Table 9 Permissible species for commercial aquaculture in Ontario.

Species	Scientific Name	Species	Scientific Name
Lake sturgeon	*Acipenser fulvescens*	Common carp	*Cyprinus carpio*
Atlantic salmon	*Salmo salar*	Goldfish	*Carassius auratus*
Brown trout	*Salmo trutta*	Brown bullhead	*Ameiurus nebulosus*
Brook trout	*Salvelinus fontinalis*	Channel catfish	*Ictalurus punctatus*
Lake trout	*Salvelinus namaycush*	American eel	*Anguilla rostrata*
Arctic char	*Salvelinus alpines*	Largemouth bass	*Micropterus salmoides*
Splake	*hybrid of Salvelinus fontinalis and Salvelinus namaycush*	Tilapia of the genera	*Oreochromis, Sarotheradon, Tilapia*
Chinook salmon	*Oncorhynchus tshawytscha*	Smallmouth bass	*Micropterus dolomieu*
Coho salmon	*Oncorhynchus kisutch*	Bluegill	*Lepomis macrochirus*
Pink salmon	*Oncorhynchus gorbuscha*	Pumpkinseed	*Lepomis gibbosus*
Rainbow trout	*Oncorhynchus mykiss*	Black crappie	*Pomoxis nigromaculatus*
Lake whitefish	*Coregonus clupeaformis*	Walleye	*Stizostedion vitreum*
Lake herring (cisco)	*Coregonus artedii*	Sauger	*Stizostedion canadense*
Muskellunge	*Esox masquinongy*	Yellow perch	*Perca flavescens*
Northern Pike	*Esox lucius*	Calico crayfish	*Orconectes immunus*
Creek chub	*Semotilus atromaculatus*	Virile crayfish	*O. virilis*
White sucker	*Catostomus commersoni*	Northern crayfish	*O. propinquus*
Bluntnose minnow	*Pimephales notatus*	Robust crayfish	*Cambarus robustus*
Fathead minnow	*Pimephales promelas*	Appalachian crayfish	*C. bartonii*
Northern redbelly dace	*Phoxinus eos*	Marsh pond snail	*Stagnicola elodes*
Finescale dace	*Phoxinus neogaeus*	Pacific white shrimp	*Litopenaeus vannamei*
Common shiner	*Luxilus cornutus*	Freshwater prawn	*Macrobrachium rosenbergii*
Golden shiner	*Notemigonus crysoleucas*	Barramundi	*Lates calcarifer*
Emerald shiner	*Notropis atherinoides*		

Among the listed species, about ten are cultured commercially in Canada (Table 9). The list of commercially cultured species identifies those for which the necessary factors for successful culture are achievable, more-or-less. Also, there are a few emerging species that may become commercially viable in the coming decade that are worth mentioning at this time (Table 10).

Table 10: Commercial and emerging aquaculture species in Canada.

Commercial Species	Emerging Species
Atlantic salmon	Lake sturgeon
Brook trout	Lake whitefish
Arctic charr	
Coho salmon	
Rainbow trout	
Barramundi	

The consideration of species for commercial culture in the Thunder Bay region can readily narrow this list even further. For example:

- The global Atlantic salmon industry is massive and highly competitive, and the species has yet to generate profits when grown in freshwater.
- Brook trout are largely produced by small-scale ventures that sell fish for pond stocking and put-and-take fisheries.
- There is one large producer of Barramundi in Ontario that services the live market in Toronto, and this market is in decline.
- Lake sturgeon may be suitable for the development of one company, but the species is not expected to lead to the development of an industry.

Therefore, the following discussion is limited to the remaining species in Table 9 – that is, arctic charr, rainbow trout/steelhead salmon[22], and lake whitefish. Coho salmon is highly similar to rainbow trout and is commercially cultured, primarily in saltwater pen systems but increasingly in land-based freshwater systems, in various Countries. Detailed evaluations for each of these species are presented below.

2.1.1 Evaluating the Commercial Culture Technology of Candidate Species

In a world with approximately 47,000 species of fish, and countless species of freshwater and marine invertebrates, it is surprising perhaps to note that only a few dozen of these species have attained the status of commercial-scale aquaculture. This is not to say that attempts to culture more species have not been made. Rather, it is indicative of the multitude of factors that must be brought under control by the aquaculturist for commercial culture to become viable.

An overview of the objectives and assumptions for each of these factors, as they pertain to commercial-scale aquaculture, are presented below. Each factor has been assessed to provide an overview of the status of commercial culture technology for each species.

[22] The technologies and practices for culture of Rainbow trout (aka steelhead salmon) and Coho salmon are essentially identical and, therefore, the species review has been combined for these species.

2.1.2 Criteria for Assessing Commercial Culture Technology

From a technological perspective, the factors important to the development of a commercial aquaculture industry include the availability of adequate supplies of seed stock through controlled reproduction of the species, the ability to raise the fry through to market-size in a culture environment where they must attain their nourishment from commercially prepared diets, and the hardiness and productivity of the species in the confines of intensive culture.

Propagation & Brood Stock Issues

The importance of genetics and proper broodstock management cannot be underestimated in the development of commercial aquaculture. Ideally, there will be several established broodstock populations for the target culture species from which eyed eggs or post-larvae (PLs) can be purchased. Importantly, a year-round supply of eyed eggs and PLs is important to enable multi-cohort stocking in a commercial fish production system as this enhances to overall productivity of the venture.

When an animal is raised under controlled feeding, care and breeding conditions, it is said to be domesticated, and it is characterized by genetic changes in behaviour, morphology, and/or physiology which result from culture under imposed conditions. Aquaculturists strive to increase productivity through the selective breeding of those individuals bearing characteristics that are most desirable for fish culture. A simple evaluation of seed stock availability has been completed for each candidate species. Emphasis has been placed upon North American stocks.

Production Issues

The fisheries biology of each candidate species must possess the physiological and behavioural characteristics that render the species suitable for large-scale commercial culture strategies. Biologically, the incubation, early-rearing, and grow-out techniques used to culture fish are all dependent upon a similar set of determinant factors.

Naturally, a reasonably fast growth rate is important for the development of a successful commercial culture operation. Because fish are poikilothermic, their metabolic rate is directly related to the temperature of their environment (i.e. water temperature). While all fish species will grow across a range of water temperatures, optimal growth generally occurs over a rather narrow temperature range, which may or may not be the same as the temperature of the water resources available at commercial culture sites. Consequently, the growth rate and the associated grow-out time required to produce a market-size fish become determinant factors in the selection of culture species. Shorter grow-out times reduce the risk associated with fish health and enhance the productivity of the system by increasing turnover time. In land-based systems, it is possible to exercise greater control over the characteristics of the rearing environment.

Since fish are being raised in a confined environment, it becomes essential to provide a diet that contains all of the nutritional requirements for the species. For many species, these requirements are well-developed and commercial diets are readily available. For other species, however, diet formulation remains incomplete. The nutritional component can be broken down into two separate components for many species, especially those that produce offspring that develop through a larval stage. These periods generally occur from hatching to fry/fingerling size, and from fry/fingerling size to market-size. Undoubtedly, it is the first phase of development that presents the greatest nutritional challenges; particularly in terms of getting the fish to accept a commercial ration. Proper nutrition is required for fast growth, maintaining a state of good health and minimizing disease. Moreover, feed presents the largest single variable cost factor in fish farming and thus efficient conversion of feed into edible fish flesh is paramount.

In nature, many species will reach the carrying capacity of the environment, which is generally limited by the availability of food. In aquaculture, however, food is no longer a limiting factor and the natural stocking density of the species is greatly exceeded to increase productivity. Under such conditions, a culture species must also be hardy to tolerate social crowding and reduced water quality, both of which lead to stress and, subsequently, disease. Moreover, if disease is encountered, veterinary medicines and therapeutic agents should be approved and available to administer treatment.

2.2 Quantification of Species for Commercial Culture

Within the scope of this study, the following assumptions have been made in assessing the technological component of each species.

Status of Culture Technology: The species is currently cultured commercially. Developmental progress is commonplace. Further core knowledge is not required. No significant challenges persist.

Seedstock Supply: Eggs and milt can be readily obtained. Fertilization is practical on a commercial scale. Commercial quantities of fry can be readily produced. The population is genetically sound.

Early Rearing Requirements: Fry are productive under intensive culture conditions. The fry accept and thrive on a commercial diet.

Grow-Out Requirements: The species' specific growth rate is sufficient to reach market size in an acceptable period. Feed conversion and other performance factors are acceptable.

Fish Health: The species is not particularly susceptible to disease. Veterinary practices are well documented for the species. Fish respond well to standard treatment regimes.

Suitability for the Region: Cultivation of the species is compatible with the environmental and socio-economic interests of the region.

Using a 5-point Likert scale, and the above evaluation criteria, the capacity to support commercial cultivation of each candidate species based on the present status of knowledge and technology has been evaluated. The 5-point scale was administered as follows:

Criterion Statement: *Technology and knowledge are sufficiently developed to support the commercial cultivation of this species.*

1	=	Strongly Disagree
2	=	Disagree
3	=	Neither Agree nor Disagree
4	=	Agree
5	=	Strongly Agree

2.2.1 Arctic Charr (*Salvelinus alpinus*)

Status of Culture Technology

Arctic charr[23] occurs naturally in many arctic and sub-arctic lakes and rivers and has a circumpolar distribution. Although mainly anadromous, there are many landlocked populations. In Canada, arctic charr are found throughout the arctic region from Alaska to Newfoundland and as far south as New Brunswick.

The arctic charr industry, both globally and in Canada, is small and highly fragmented. Global arctic charr production is estimated to be less than 10,000 tonnes per year – unfortunately, there are no reliable statistics. At about 3,500 tonnes, Iceland is the leading producer. Current charr production in Canada is about 500 tonnes and a 200-tonne expansion is just starting up at a charr farm in Manitoba[24] Charr farming is gaining momentum in Canada and elsewhere.

Arctic charr has been the subject of considerable interest for the aquaculture industry in Canada because it displays good growth at low temperatures typical in the Canadian environment, can be reared at high densities and has a relatively high niche market value. Arctic charr are farmed using essentially the same techniques and facilities as are used for rainbow trout and Atlantic salmon. However, the development of the industry has been constrained by slow growth rates, the cold-water requirements for the fish (many areas are too warm for arctic charr culture), considerable size variability within cohorts, and largely undeveloped markets. Attempts to culture arctic charr under production conditions have been inconsistent to date and this may be due to a failure to recognize that arctic charr have biological and environmental requirements that differ from those of other salmonids in subtle, but important, ways.

The arctic charr industry enjoys access to the same infrastructure that supports the Atlantic salmon and rainbow trout industries. Feeds formulated for other salmonids are suitable for arctic charr at all life stages, disease diagnostic services and vaccines and therapeutic agents are all relevant to arctic charr, and the equipment available for feeding, inventory control, and fish handling are standard.

Seed Stock Supply

Three strains of Arctic charr have been used to develop brood stocks in Canada: the Nauyuk Lake and Tree River strains from the Northwest Territories and the Fraser River strain from Labrador.

[23] The genus is commonly spelled two ways – charr and char. Both are considered acceptable.

[24] https://www.aquaculturealliance.org/advocate/project-seeks-to-synergize-canadas-arctic-charr-industry/

Unfortunately, the Nauyuk and Fraser River strains were developed from extremely small founding populations of two to four families.

To date, only two organizations in Canada have attempted to develop selectively bred arctic charr to yield traits favourable to aquaculture such as growth rate, dress-out yield, and disease resistance. Unfortunately, arctic charr eggs are only available at two times per year. In intensive culture systems, productivity is improved substantially if eggs are available at least three times per year and preferably four times per year.

Many issues must be addressed in developing a viable arctic charr aquaculture industry. Brood stocks need to be further developed to address some common challenges, e.g. populations are highly variable in terms of response to water temperature, growth rate, age and size at maturity, and body morphology. Initially, efforts are required to expand the availably of eyed eggs.

Early Rearing Requirements

Egg incubation and fry rearing techniques are essentially the same as for other salmonids. Eggs are incubated at lower water temperatures, usually less than 8°C or lower to ensure good egg survival. Charr eggs may be more sensitive than other salmonid eggs to vibration and other disturbances. Arctic charr fry are small compared to trout and salmon and can be more difficult to introduce to manufactured feeds.

Grow-out Requirements

Arctic charr can be grown-out to market size in the same tanks and cages as other salmonids. Arctic charr tend to school and tolerate high stocking densities (>100 kg/m^3). For these reasons, and their ability to grow at low temperatures, arctic charr are appealing to culture. The optimum temperature for growth of Arctic charr is 10 to 13°C and they will survive in water temperatures as low as -1°C. Growth rate and survival are reduced at temperatures exceeding 15°C. For net-pen ventures, it is essential that the nets are deep enough to enable the fish to selectively avoid warm surface waters.

Growth of arctic charr is highly variable and tends to slow with increasing age. Within a single lot, up to 30% of the fish may never grow to harvest size. It is believed that this stunting is genetic in origin. Selective breeding is reducing the degree of size variability in some strains.

Fish Health

The same viral, bacterial and parasitic disease agents that infect other salmonids affect arctic charr. Charr has been found to be sensitive to diseases such as furunculosis, vibriosis, bacterial kidney disease and to fungal infection. Good husbandry practices and excellent water quality are keys to controlling disease outbreaks.

Suitability for the Thunder Bay Region

The cooler water supplies in the region would lend themselves to the culture of arctic charr.

2.2.2 Rainbow Trout (*Oncorhynchus mykiss*)

Status of Culture Technology

Native to the west coast of North America, rainbow trout have now been introduced to every continent and are farmed in many countries with a temperate climate. The technology for trout culture is well developed and is based on more than 100 years of culture experience by resource management agencies. Commercial production of trout began in Canada in the late1950s – mainly for stocking private ponds. In the 1970s, producers began farming trout to market size for restaurant and foodservice markets. Today, the rainbow trout industry in Canada produces ~10,000 tonnes annually with a market value of ~$60 million. Rainbow trout are produced in all provinces using both land-based and net-pen technologies. The vast majority of production (>90%) is from net-pen operations. Approximately 70% of all trout production in Canada occurs in Ontario.

Land-based facilities are built on sources of high-quality water available in copious quantities. Modern farms use a variety of sizes of fibreglass, steel or concrete tanks for rearing fish from the juvenile stage to market size. Land-based facilities are normally flow-through, although recirculation systems are becoming increasingly popular. As competition increases and producers strive to lower their production costs, many land-based facilities have been converted to the production of fingerlings. The majority of food-fish production is now from grow-out operations utilizing net-pen technology since the total cost of production is generally lower in such systems, thus enhancing the economic competitiveness of these ventures.

Rainbow trout grow rapidly to market size at high densities with efficient food conversion. They are generally resistant to disease and can be marketed before sexual maturity causes deterioration of the flesh quality. Domesticated brood stocks with many generations of selection are available. Production problems are usually disease-related and caused by poor water quality, poor facility design and/or inexperience in husbandry practices. Depending on the water supply and temperature regime, trout are reared to a weight of about one-kilogram in 15 to 18 months. Cage systems in lakes take advantage of warm surface waters during the summer for more rapid growth and the production of larger fish (1 to 2 kg) for the fillet trade.

The trout farming industry enjoys access to established support infrastructure. The nutritional requirements of rainbow trout are well known, and feed formulation is well developed. Several companies manufacture high-quality feeds. Disease diagnostic services are readily available, and disease control strategies are well developed. Specialized equipment for feeding, inventory control, and handling fish, although expensive, is readily available from several companies worldwide.

Seed Stock Supply

Rainbow trout have been domesticated to a large extent. Many hatcheries specialize in maintaining brood stocks and produce eggs and fingerlings for sale to grow-out operations. Two companies in the United States – Troutlodge® and Riverence® – supply about 70% of the eyed eggs to the Canadian industry.

Rainbow trout have been selectively bred for generations to improve traits desirable to commercial culture ventures: namely rapid growth, good feed conversion, high fillet yield, and late maturity. The timing of reproduction has been extended through selective breeding, photoperiod and temperature control and use of hormones to produce eggs all year round. Technology is also available for the production of all-female stocks to overcome the problem of sexual maturity in the larger fish required for filleting. Triploid (sterile) stocks can also be produced if there is concern that escaped farm fish will breed with wild fish populations.

Spawning techniques for rainbow trout are well known. Dry fertilization techniques are used when mixing the eggs and milt. Each female is capable of producing 1,100 to 1,400 eggs per kilogram of body weight.

Early Rearing Requirements

Hatchery production techniques have evolved into a routine that achieves high and consistent survival. Eggs can be incubated in a variety of systems, including “bell jars”, hatching boxes or trays suspended in troughs, and specialized tray incubation systems (MariSource™ incubation racks). Hatchery procedures involve the maintenance of flow rates required to supply dissolved oxygen to the developing eggs and the control of fungal infection.

Hatched fry are held in small circular or rectangular fibreglass tanks supplied with high-quality water at an exchange rate of 1.0 to 1.5 tank volumes per hour. The optimum water temperature for feeding and growth of fry is 12 to 16°C. Dissolved oxygen concentrations must be maintained above 85% saturation. Formulated starter diets are used to initiate the fry to feeding, once the yolk sac is absorbed. This is a critical stage in the development of the fry and careful and frequent presentation of the feed is essential. As the fish grow, feeding becomes less frequent, and the fish are moved to larger tanks as required until they are large enough to meet the requirements of the grow-out facility.

Grow-out Requirements

Grow-out in land-based facilities takes place in large tanks. The water velocity in the tanks provides the fish with exercise and promotes growth. High-quality water is required with sufficient flow to exchange the water volume of the tank every 30 to 60 minutes, in general. Rainbow trout are typically reared at densities of 60 to 70 kg/m^3 provided that dissolved oxygen concentrations can be maintained above 85% saturation.

Rainbow trout are also grown-out in net pens suspended in lakes or oceans. Sites must be carefully selected for water temperature, currents and protection from storms and ice. The water temperature should not rise much above 20°C in summer. The optimum temperature for growth in rainbow trout is 15°C. Currents must be adequate to remove metabolic waste products, principally ammonia, and faeces from the cage vicinity and deliver ample quantities of oxygenated water to the fish. The velocity of water currents and their impact on exchange rates and oxygen concentration within the net pens is a principal factor limiting production in net pens.

Fish Health

A wide variety of viral, bacterial and parasitic disease agents are known to infect rainbow trout, however, the disease agents are well known and diagnostic techniques have been developed. Rainbow trout are generally resistant to diseases provided that they are not stressed by poor water quality or husbandry practices. Vaccines and therapeutic agents can be used to control the most prevalent diseases, and veterinary services are readily available.

Suitability for the Thunder Bay Region

Rainbow trout are highly suitable for culture in the region.

2.2.3 Lake Whitefish (*Coregonus clupeaformis*)

Status of Culture Technology

The lake whitefish, a member of the salmon family, inhabits oligotrophic lake systems throughout mainland Canada and Alaska. Lake whitefish are often associated with lake trout populations as both species require the same general thermal niche and spawning habitat. Lake whitefish is the most valuable commercial freshwater fish in Canada (due largely to volume, not unit price) and also supports substantial sport fisheries in some areas. Since the late 1800s, resource management agencies in Canada and the United States have cultured and stocked millions of lake whitefish eyed eggs and fry. Returns from fry stocking were poor and, therefore, by the 1960s, efforts to culture lake whitefish were halted. Consequently, information on culturing whitefish is sparse.

The Ontario Ministry of Natural Resources and Forestry has been a leader in developing lake whitefish culture techniques and developed an intensive culture program relying solely on manufactured feeds. Whitefish eggs and fry are small compared with other salmonids and the yolk-sac is consumed within 24 hours of hatch. Therefore, culturing whitefish at the initial stages is more like culturing cool water fishes, such as walleye and muskellunge, than salmon or trout. Eggs are collected from wild stocks and incubated in bell jars. Fry are reared in conical-bottomed circular tanks and initially fed a commercial larval fish diet followed by weaning onto a trout diet. The survival rate is high and growth is fairly rapid. Advanced rearing has been done in both circular tanks and raceways at reasonably high densities.

Although, resource management agencies have had success intensively rearing lake whitefish to sizes of 50 grams, the viability of raising whitefish in commercial aquaculture ventures has not been demonstrated. One private fish farm in Ontario is developing the technologies and practices for rearing whitefish in a net pen. After several years, and operating with a minimal budget, promising results have yet to emerge.

For lake whitefish to be raised commercially, several hurdles must be cleared. At present, no broodstock exists for lake whitefish. For a fish to become commercially viable, brood stocks must be developed which have been selectively bred to improve traits advantageous to an aquaculture venture, such as growth rate, dress-out yield, and disease resistance. Lake whitefish appear to perform well on commercial trout feed formulations and have been shown to grow reasonably quickly in hatcheries. One advantage of lake whitefish is that pigmented diets are not required, as the flesh is naturally white, which lowers the feed cost significantly compared to that for trout culture. Lake whitefish are probably subject to the same disease agents as other salmonids, but culture has not been sufficiently widespread to provide a history of disease susceptibility in this species.

Seed Stock Supply

At present, there are no captive or domesticated brood stocks for lake whitefish. Resource management agencies collect eggs from wild populations.

Lake whitefish spawn in late November when the water temperature is 5 to 6^{o}C. Eggs are deposited over large rock rubble and sand shoals in 2 to 4 metres of water. The parent fish are normally captured in trap nets set on the spawning shoals for spawning operations. The number of eggs produced per kilogram of female body weight varies from lake to lake; Lake Erie whitefish produce about 35,000 eggs/kg, while Lake Huron populations produce only 18,000 eggs/kg of female body weight.

Spawning techniques are similar to those used for other salmonids. Eggs and milt are hand stripped from the brood fish. Dry fertilization is used. Following water-hardening, eggs can be shipped to hatcheries in conventional egg shipping containers. Lake whitefish eggs are small (30,000 - 35,000 per litre) compared to rainbow trout (8,000 - 10,000 per litre).

A small aquaculture venture could depend on collecting eggs from wild populations during the initial phase of development. However, for a mature aquaculture lake whitefish industry to develop, domesticated brood stocks are essential. Such brood stocks would benefit from breeding techniques aimed at enhancing traits important to commercial production such as growth rate, disease resistance and dress-out percentage. Fortunately, lake whitefish are widely distributed and populations are generally large enough, that collecting eggs from a sufficiently broad founder population should not be a problem if an aquaculture venture wished to pursue developing a broodstock.

Early Rearing Requirements

Lake whitefish eggs are incubated in standard upwelling “bell-jars”. One to two litres of eggs are incubated in a 6-litre jar. Unlike trout and salmon eggs, whitefish eggs require gentle rolling during the incubation process and therefore no substrate is used in the jars. Water flow is sufficient to gently roll the eggs while minimizing water velocity. Resource management agencies normally incubate the eggs at natural water temperatures of 2.0 to 4.0^{o}C and hatching requires 140 to 150 days (approximately 300 degree-days). Survival of eggs is usually greater than 90 percent. The optimum temperature for incubation in a commercial venture is not known. Warmer incubation temperatures may be advantageous in accelerating the development process provided that high survival rates can be maintained. Lake whitefish eggs are removed from the bell jars before hatch and placed in small batches into submerged containers in the early rearing units. A sudden increase in water temperature induces hatching and all larvae hatch within a few hours. The larvae swim up and out of the containers leaving the egg casings behind.

The larvae are reared in relatively small (500 litres) early rearing units. Deep, conical-bottomed circular tanks provide the best results. The larvae are initially confined to the upper portion of the unit with a screen-bottomed circular basket, which fits snugly in the tank. Initially photo-positive, they quickly become photo-negative so light intensities must be kept below 250 lux. Water temperature is initially set at 6 to 8^{o}C and is raised by 1.5 degrees per week to the optimum temperature for growth of 14^{o}C. The temperature range for growth is narrow and the growth rate drops rapidly below 11^{o}C or above 16^{o}C. Water flows are initially set to provide a tank exchange rate of once per hour, increasing to 1.5 times per hour as the fish grow. Maximum rearing densities are 18 kg/m^{3}. Dissolved oxygen must be maintained above 85% saturation.

Compared to other salmonids, lake whitefish larvae are small (11 to 14 mg at hatching), swim-up almost immediately, and the small yolk-sac is depleted rapidly. The larvae begin exogenous feeding within 24 hours of hatching. The introduction to feed is extremely important for success. Immediate availability of a nutritious and palatable diet is critical. In the natural environment, lake whitefish larvae are planktivores, feeding on rotifers, phytoplankton and small cladocerans such as *Daphnia*. Providing natural feed is labour-intensive and expensive, thus culture efforts have focused on the use of manufactured feeds. Success in the intensive culture of lake whitefish has been achieved using Japanese commercial larval diets - Biokyowa-B and/or Otohime – although neither is currently able to be imported into Canada. Low-intensity lighting is maintained through-out the day (24 hours) to promote feeding. The fry are fed in very small amounts every 5 to 10 minutes using automatic feeders. Once the fry reaches an average size of 0.5 grams they are slowly weaned onto standard trout diet.

Grow-out Requirements

Advanced rearing of lake whitefish has been done in circular tanks, raceways and net pens. Optimum growth is achieved at water temperatures of 14 to 15^{o}C; growth rate declines below 11^{o}C and above 16^{o}C. At water temperatures above 16^{o}C, lake whitefish become more susceptible to disease. Dissolved oxygen must be maintained above 70% saturation.

Although production traits have not been measured under commercial conditions, lake whitefish appear to grow rapidly, approaching the growth rates of domestic rainbow trout, under optimal conditions and tolerate reasonably high rearing densities (40 to 60 kg/m^3). Whitefish can be raised successfully on commercial trout diets. With their naturally white flesh, unpigmented diets are used providing a significant cost reduction over other salmonids. Lake whitefish are sensitive to handling and lose scales easily, making standard salmonid handling techniques unsuitable for whitefish.

Lake whitefish appear to be suitable for commercial production under intensive conditions. However, the viability of commercial culture remains to be demonstrated and production techniques require further refinement. Growth rates and maximum rearing densities under commercial production conditions have yet to be defined. Special handling techniques must be developed to avoid scale loss and stress on the fish. The development of special whitefish diets may be advantageous.

Fish Health

Lake whitefish are highly susceptible to stress. Scales are easily lost during handling leaving the fish vulnerable to osmotic stress and infection. Any major disturbance, such as transfers between tanks or taking inventory, usually results in an outbreak of common diseases such as bacterial gill disease. Whitefish have also been found to be susceptible to fungal infections and *Columnaris* disease. In the wild, whitefish are vulnerable to parasitic infections. High standards of facility hygiene and husbandry, excellent water quality and very careful handling are essential to maintain the health of cultured whitefish.

Suitability for the Thunder Bay Region

The biophysical resources of the region appear to be suitable for whitefish aquaculture, however, the commercial culture of lake whitefish would be a pioneering effort at this time. While intensive culture techniques developed in government hatcheries, the financial viability under commercial culture conditions has yet to be demonstrated.

2.2.4 Comparative Evaluation of Candidate Culture Species

Using the ranking system presented above, the 3 short-listed species were evaluated for their commercial culture potential in the Thunder Bay region. Not surprisingly, rainbow trout scored highest; largely owing to the long-standing success associated with the commercial cultivation of the species in Canada. Of the remaining species, arctic charr are preferable over whitefish owing to the commercial culture status of charr and the absence of proven technologies, as yet, for whitefish.

Table 11: Comparative evaluation of three potential species for commercial aquaculture development in the vicinity of Thunder Bay.

Species: / Factors:	Arctic Charr	Rainbow Trout	Lake Whitefish
Status of Culture Technology	4	5	2
Seedstock Supply	2	5	1
Early Rearing Requirements	4	5	3
Growout Requirements	4	5	3
Fish Health	4	4	3
Suitability for the Region	4	5	4
Overall Score:	22	29	16

It is important to note that with the continuous improvement in the development of land-based system technology, partial or full life cycle production of other species (e.g. eels, sturgeon, etc.) may be economically viable and suitable for consideration considering the advantages of controlled system environments.

2.3 Production Rearing Systems

There are two primary grow-out systems used in Ontario for the commercial production of aquaculture species;

(a) Land-based systems, which come in a variety of shapes and sizes including freshwater ponds, raceways, and circular tanks. These systems are largely determined by the volume of water that is available and how the operators choose to use this resource – i.e., as flow-through, partial reuse or full recirculation of the water (RAS)[25]; and;

(b), Net Pen systems, which also come in a variety of sizes. Most of the commercial net-pen production of aquaculture species is done in salt water and use high-density polyethylene (HDPE) circular pens. The environmental conditions in the Great Lakes make the use of the HDPE cages less efficient and most of the current production is done using cages made from steel pontoons.

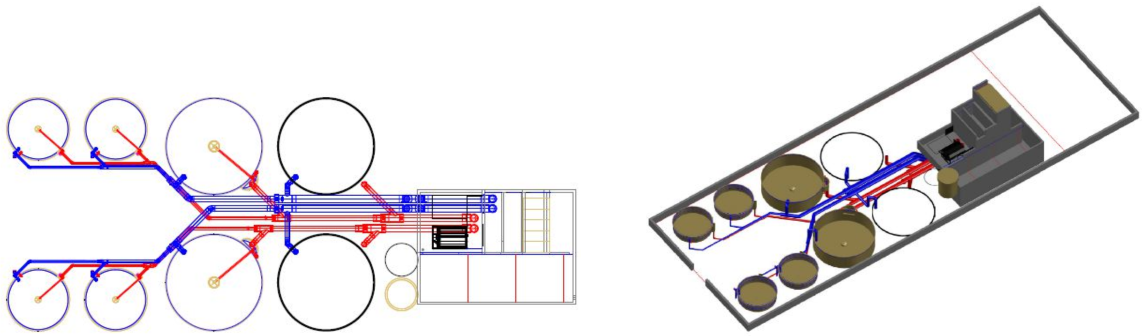
[25] RAS Definition adapted from: https://www.aquacultureid.com/recirculating-aquaculture-system: In a recirculating aquaculture system the culture water is purified and reused continuously. It provides a constant and controlled environment for the fish using an almost completely closed circuit. The produced waste products; solid waste, ammonium and CO2, are either removed or converted into non-toxic products by the system components. The purified water is subsequently saturated with oxygen and returned to the fish tanks. 90% or more of the culture water can be reused keeping the water and energy requirements an absolute minimum.

2.3.1 Land-Based Systems

Designing an intensive aquaculture system for the commercial culture of fish in a land-based facility requires an optimal scale of production to establish a viable operation. Efforts should be made to optimize fish production and efficiency by applying aquacultural bio-engineering technologies and principles. That is, the facility must be designed to be simultaneously technically and mechanically effective and biologically productive; it must meet the environmental needs of the fish (e.g. water quality management, biosecurity) and the management needs of the fish culturist (e.g. feeding, grading, handling) in a mechanically efficient facility (e.g. low operational and maintenance costs). Today most new intensive systems are based on RAS technologies.

Figure 2: Examples of Aquaculture Production Systems in Ontario.
photos courtesy of Canadian Aquaculture Systems Inc.

Figure 3: Sample CAD drawings for a recirculating aquaculture facility showing circular tank layout



2.3.2 Net Pen Systems

Designing an intensive aquaculture system for the commercial culture of fish in a net pen-based facility will be influenced by the site selection criteria. As the system is largely "passive" (no pumped water), efforts should be made to optimize fish production by applying aquacultural bio-engineering technologies and principles that meet the environmental needs of the fish (e.g. water quality management, biosecurity) and the management needs of the fish culturist (e.g. feeding, grading, handling) in a mechanically efficient facility (e.g. low operational and maintenance costs).

Once the site selection criteria are established and a site has been identified with an aquaculture lease, system design focussed on the net pen design and mooring systems

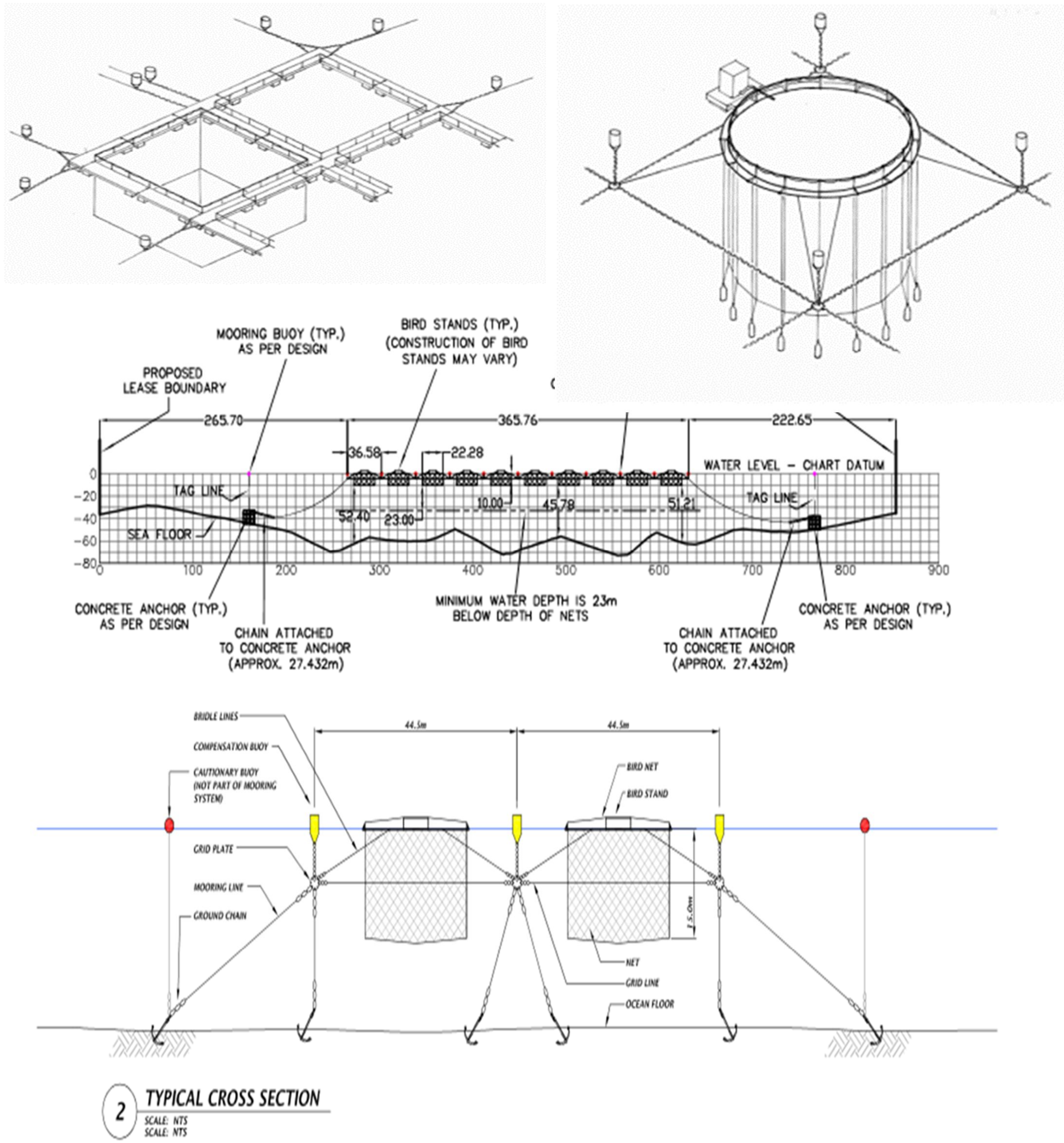
Net Dimensions
- Minimum area in cubic meters of rearing volume
- Maximum rearing density of the fish
- Netting materials
- Net weight systems
- Predator control – i.e. Top nets to prevent bird strikes.

Pontoon Size
- Number of units
- Type of floatation
- Mooring systems – type and number

Figure 4: Example of a Standard calculation for determining net dimensions

Size (m)	Dia. (m)	Radius	Pie	Area (m²)	Depth (m)	Vol (m)³	Density (kg/m³)	Load (kg)	Avg Wt (kg)	Fish No	Survival	Initial Stocking
50.00	15.90	7.96	3.14	198.94	10.00	1989	20	39789	2.03	19600	80%	24500
70.00	22.30	11.14	3.14	389.93	10.00	3899	20	77986	2.03	38417	80%	48021
90.00	28.60	14.32	3.14	644.58	10.00	6446	20	128915	2.03	63505	80%	79381
15x15	Length (m)			225.00	10.00	2250	18	40500	2.03	19951	80%	24938
24x24	Length (m)			576.00	10.00	5760	20	115200	2.03	56749	80%	70936

Figure 5: Example of the net pen system schematics[26] and its location on the aquaculture lease



[26] Marine finfish farms. Net cage Design and operation. Reference number ISO/FDIS 16488:2015(E)

2.3.3 Aquaponics

Aquaponics (the combination of aquaculture and hydroponic technologies) can be an effective means to utilize residual nutrients from fish farm operations to produce a second marketable crop. Fresh fish manure has levels of macro-nutrients (N, P, Ca, and Mg) and micro-nutrients that are similar to those found in other livestock manures. With the correct balance of nutrients and appropriate production technology, aquaponics can be particularly effective. Data from Ontario trout farms demonstrates that fish manure is similar to other livestock manures (Naylor et al. 1999). The overall composition of trout manure is presented in Table 12.

One of the challenges to the successful application of aquaponic technology has been the integrated management of aquaculture and hydroponic production systems so that both become productive, profitable business units. Conventionally, aquaponics is the culture of fish and plants in a system where the water circulates continuously between the two production systems; that is, fish and plants are grown in the same water. An alternative approach is to produce fish in an aquaculture system and then use the nutrient-enriched process effluent from the fish farm in a hydroponic system. In this latter ‘decoupled’ scenario, the two ventures are vertically integrated - fish are produced in a system designed for optimal production of fish and then the process effluent from fish culture, which must be treated before discharge, is further utilized in an adjacent hydroponic facility to take advantage of the available water and nutrients to produce a second marketable crop. There are several conventional aquaponic ventures throughout Canada. They tend to be smaller owner-operated enterprises focussed on niche markets. The overall financial viability of these ventures is unclear.

Table 12: Chemical composition of manure from Ontario trout farms[27]

Element	ON Trout Farms	Aa	Ab	Ac	B	Ca	Cb	D	Ea	Eb
(%)										
N	2.84	4.85	2.17	1.41	3.3	3.15-5.49	0.87	4.8	2.95-16.11	1.78-15.3
P	2.55	1.79	2.99	1.49	1.03	1.34-3.51	0.70	2.22	0.88-6.6	0.35-1.8
K	0.10	0.15	0.46	0.71	0.03	0.29-0.43	0.36	0.047	0.05-0.96	0.29-0.8
Ca	6.99	-	-	-	-	-	-	6.1	1.18-4.43	0.34-2.7
Mg	0.53	-	-	-	-	-	-	0.31	0.18-0.44	0.35-0.6
C	-	-	-	-	25	-	-	-	11.2-48.5	9.3-70.6
Na	-	-	-	-	-	-	-	0.20	230-3510	350-520
S	-	-	-	-	-	-	-	0.52	-	-
Cl	-	-	-	-	-	-	-	-	60-190	20-150
(ppm)										
Cu	33.4	49.0	-	-	-	-	-	40	0	0-60
Fe	1942	-	-	-	-	-	-	769	-	-
Mn	487.8	-	-	-	-	-	-	150	-	-
Zn	604.9	342.0	-	-	-	-	-	458	130-590	160-500
As	2.20	-	-	-	-	-	-	-	-	-
Cd	1.13	7.6	-	-	-	-	-	0.20	-	-
Co	1.82	-	-	-	-	-	-	0.59	-	-
Cr	3.86	91.0	-	-	-	-	-	2.6	-	-
Hg	0.05	-	-	-	-	-	-	<0.03	-	-
Ni	4.94	60.0	-	-	-	-	-	1.0	-	-
Pb	5.54	92.0	-	-	-	-	-	0.92	-	-
Se	0.50	-	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	10	-	-
Mo	-	-	-	-	-	-	-	0.41	-	-

[27] Naylor, S.J., R.D. Moccia and G.M. Durant (1999). The chemical composition of settleable solid fish waste (manure) from commercial rainbow trout farms in Ontario, Canada. N. Amer. J. Aquaculture. 61:21-26.

2.4 Sites for Commercial Aquaculture - Preliminary Scan[28]

The principal interest in aquaculture is to install an aquatic facility that is compatible with the ecosystem, socially acceptable and economically feasible. Suitable potential development sites will require the technical (e.g. water supply, utilities, etc.), environmental (effluent and solid waste discharge, surrounding land-uses and habitats, etc.), regulatory (e.g. zoning, permits, etc.) and general business (e.g. transportation, market access, labour, infrastructure, etc.) characteristics that meet the requirements for establishing a viable aquaculture venture.

2.4.1 Land-Based Activities

In addition to greenfield spaces, it is expected that within the Thunder Bay region there could be several business development parks and vacant light industrial and warehousing sites that offer the characteristics and amenities for aquaculture development. These sites consist of two principal types: (1) New development parks specifically designed to attract businesses to a region; and (2) Re-purposed sites that were previously used for food processing, manufacturing and/or warehousing by corporations that have relocated or ceased operations. The sites generally have a considerable amount of infrastructure in place and may have access to economic development funding to stimulate investment. The characteristics of an ideal site are provided in Table 13.

Table 13: Land Based Site Selection Criteria

Criterion	Metrics
Water Supply	• >50 gpm, preferably from a bio secure groundwater source although municipal and/or surface waters sources will be considered
Water Chemistry	• Basic water chemistry characteristics • Identification of any contaminants that could compromise fish health or product quality
Land Area and Building Size	• Sufficient land area to enable staff parking and transport truck access • Minimum building area of 12,000 square feet; capacity to expand is beneficial • For existing buildings, the space between vertical columns should be > 20 feet and the floor-to-ceiling (under-side of roof trusses) should be 14 feet • Capability to manage facility security and biosecurity
Infrastructure	• 3-phase, 575-volt power supply • Ease-of-access to good roads and highways • Capacity to discharge effluent into municipal sewers or to surface waters with appropriate effluent treatment; effluent quality will meet the provincial standards for discharge to surface waters
Other	• General description of the property and its attributes • Site maps, drawings and/or satellite images of the property • Map of the general location and surrounding land-uses • Potential availability of economic development funding

[28] Prepared by D. Stechey- Canadian Aquaculture Systems Inc 2020

2.4.2 Lake Based Activities

Net Pen aquaculture activities are usually established in nearshore coastal areas, which typically are considered part of the public or common domain. These areas are often subject to pressure from different interests and other priorities in respect of their use. Within the Thunder Bay region, several areas offer the characteristics and amenities potentially suitable for net-pen aquaculture development. The characteristics of an ideal site are provided in Table 14

Ideally, the scoping process for land-based and lake-based activities would identify a cluster of sites using all known information.

First step: identify cluster areas using all known information – per the criteria listed above

Second step: On-site profiling. For lake-based sites, this typically entails diving the site and deploying equipment to record current speed/prevailing direction, depth contours, temp/oxygen profiles, sediment assessment.

Third step: Suitability Analysis using the criteria outlined above:

Table 14: Lake Based Site Selection Criteria

Criterion	Metrics
Area Bathymetry	• Minimum depth of 10-20 meters • Non-confined & well-oxygenated hypolimnion • Area suitable for the deployment of anchors and mooring systems. • Identification of any potential hazards that could interfere with the farming operations. • Outside navigational channels used by commercial freight traffic
Currents and Fetch	• Protection from strong winds and waves • Current speed between 1-2 knots
Adjacent Uses	• ~5 km from municipal or industrial intakes and discharges
Critical Habitat	• Avoid areas with critical wildlife habitat • Avoid proximity to underwater pipelines and cables
Infrastructure Access	• Proximity Existing service roads • Land base for dock facilities (loading/unloading), storage and mechanical shops • Mobile phone and radio coverage (communication)
Water Quality	• Optimal water temperatures for growth 16–18°C; <22°C • Suitable dissolved oxygen (DO); >75% saturation • Low level of total phosphorus (TP) • Identification of any contaminants that could compromise fish health or product quality
Other	• Site maps, drawings and/or satellite images of the location • Map of the general location and surrounding uses • Potential biosecurity risks (oil spills, navigation, vandalism, etc.)

A preliminary assessment of the suitability of waters along the North Shore of Lake Superior for the potential development of a net pen aquaculture facility was conducted. The review looked at the shoreline from Copper Island west of Schreiber to Victoria Island south of Thunder Bay, an area of approximately 180 km. This review is not based on a site inspection by the authors.

Factors evaluated in determining potential sites included suitable physical characteristics (bathymetry, currents, fetch, wave height, water temperature) and special concerns (contaminants, environmental restraints, municipal infrastructure) that limited or rendered an area unsuitable. A discussion of the evaluation criteria is provided below. Limits of the review are indicated on the maps in Appendix A.

Bathymetry

The primary factor used in the evaluation was a minimum water depth of 18 to 20 m. Conventional net pens are approximately 15 m deep and require an additional 5 m to allow circulation beneath the cages. Additional water depths may be required if submersible cages are installed. Cages are submerged during ice-off conditions to avoid damage from moving ice.

Using these criteria, the area within the Port of Thunder Bay and Fort William First Nation break walls would not be suitable for the establishment or overwintering of cages due to their shallow nature (less than 15 m).

Embayments with enclosed hypolimnions, the bottom waters below the thermocline that are isolated from mixing during the summer stratification period, are not suitable for siting cage facilities. As described in *Recommendations for Operational Water Quality Monitoring at Net pen culture Aquaculture Operations* (MOE 2001), enclosed hypolimnions may lead to a buildup of organic matter resulting in reduced oxygen levels in the bottom waters.

Current / Fetch / Climate

The main current through this area is generally towards the east and discharge to Lake Huron, with local flow patterns influenced by inflows and islands. Based on the wind rose data from monitoring Buoy 45001 in northern Lake Superior, winds are predominantly from the southwest, with the southeast direction secondary. Wind speeds range from 5 to 15 knots (9 to 28 km/hr) for 62% of the time. Average wave heights are 0.5 m (maximum 3.3 m) during summer months and highest during the winter months (average 1.5 m; maximum 5 m). Climatology data for Buoy 45001 is provided in Appendix A.

Based on these conditions, cage sites would require shelter along their southern exposure and open fetch distances should be minimized. This also minimizes impacts associated with ice movement during spring break-up or periods of milder winter weather.

Average monthly water temperatures at Buoy 45001 (Appendix A) range from a low of 1.5 C in February to 13 C in August and September in the main lake. Embayments located along the north shore would experience warmer temperatures than experienced in the lake basin, suitable for rearing rainbow trout. Impacts associated with climate change will potentially result in warming waters and reduced ice cover.

Area of Concern (AOC) - Lake Superior National Marine Conservation Area park[29]

The NMCA is the largest freshwater protected area in the world. Traditional fishing, hunting, and other renewable resource extraction activities are permitted within the Lake Superior NMCA. These activities are managed to protect natural, self-regulating ecosystems and to maintain biological diversity. In the context of this interim management plan, the Ontario Ministry of Natural Resources regulates activities such as recreational and commercial fishing, hunting, and trapping while Fisheries and Oceans Canada continues to manage fish habitat programs. Parks Canada plays a lead and/or partnering role in fish habitat management, research and monitoring to assist in the protection of resources and to ensure ecosystem health. In so doing, Parks Canada would work with the Ontario Ministry of Natural Resources and Fisheries and Oceans Canada.

The Thunder Bay Area of Concern (AOC) and Nipigon Bay AOC are located within the review limits. Designated as areas with impaired uses in the late 1980s associated with industrial and municipal discharges, significant cleanup and recovery have occurred in both areas.

In Thunder Bay, remedial actions controlling municipal and industrial wastewater treatment facilities have resulted in improved water quality, fish habitat, and fish and wildlife populations. However, sediment contamination persists in North Harbour.

In Nipigon Bay, major improvements in water quality have occurred with upgrades at the upstream pulp and paper mill and implementation of secondary treatment at the municipal wastewater treatment plants. Changes in the operations of hydroelectric dams on the Nipigon River more closely resemble natural flow conditions in the river and bay area. There are no remaining impairments and removal of the AOC designation is proposed. As such, the establishment of cage facilities in Nipigon Bay is reasonable.

In general, total phosphorus (TP) concentrations in Lake Superior are characterized as low, averaging approximately 5 ug/L in nearshore areas. This is well below the Ministry of Environment, Conservation and Parks proposed guideline of 10 ug/L for protection from nuisance algae of waters of exceptional quality (MOE 1994). The occurrence of harmful blooms and nuisance algae are generally low and not a concern in Lake Superior. Cage facilities in Ontario are licenced under Provincial regulations such that operations and on-going monitoring maintain TP levels below this criterion.

Most of the shoreline area reviewed, particularly to the east, is undeveloped with limited municipal infrastructure. Municipal water intakes are located to the north of the Port of Thunder Bay, and residential development along the lakeshore, both seasonal and permanent, may utilize lake water as a drinking water supply. This is more significant in the area surrounding the City of Thunder Bay. Undeveloped areas provide access constraints to areas of potential cage sites as docks, wharves and boat launch sites are limited and would need to be established for offshore areas.

Upon selection of a preferred site, further assessment of critical habitat, species at risk (SAR), adjacent infrastructure and environmental quality would be required. Completion of detailed baseline monitoring would be required at any site before proceeding to confirm the suitability of the local site conditions. Study components include water quality monitoring throughout the open-water season, including temperature and current conditions, sediment chemistry, benthic macroinvertebrate community assessment, SAR, a review of fish community information and habitat assessment.

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[29] https://www.pc.gc.ca/en/amnc-nmca/on/super/info/index/gestion-management-2016

Preliminary Scan Conclusion

Based on the evaluation criteria, three areas for the potential establishment of cages sites have been identified: Pie Island to Victoria Island, the mouth of Black Bay and Nipigon Bay. A review of each follows in order of suitability:

Nipigon Bay

A total of four areas within the bay have been identified, primarily based on suitable water depths, assumed good flushing rates from the Nipigon River and shelter from southerly winds provided by Copper, Wilson and Simpson Islands (see Map in Appendix A).

Depending on land tenure along the north shore, the establishment of a facility attached to shore may be feasible as water depths greater than 20 m are close to shore at some locations. Water temperature warmer than the main lake would be anticipated in this sheltered setting. The area is adjacent to Hwy 17 which provides ease of access for shipping. Off-shore sites accessed by boat or across the ice are located on the leeward side of the three islands. Land tenure, access, and development of shore-based infrastructure (feed storage, shipping and receiving, boat launch, etc.) need to be determined.

Pie Island to Victoria Island and Area

The two areas have suitable water depths, good flushing and sheltered from prevailing southern winds (see Map in Appendix A). Much of the area along Pie Island to Thomson Island provides sufficient depth for the establishment of facilities attached to the shore, subject to suitable shore geography.

As Thomson Island is a Provincial Nature Preserve, net-pen aquaculture may not be a permitted use adjacent to this island. Offshore sites, between these islands and the main shore, or between Pie Island and the shore are feasible based on water depths. Similar to Nipigon Bay, infrastructure appears to be limited to service this area. Water temperatures may be slightly cooler than Nipigon as this area is more proximal to the lake basin.

Black Bay

While water depths throughout the length of Black Bay exceed 20 m, there is an area north of Grey and Arno Island with shallower waters resulting in an enclosed hypolimnion (see Map in Appendix A). Suitable water depths with an open hypolimnion occur west of the islands for net-pen aquaculture. Water temperatures would be marginally warmer than those measured in the main lake basin. Any site within the bay would be off-shore and require access by boat or over ice. Shelter is limited, dependant on proximity to the east and west shorelines. Sleeping Giant Provincial Park is located along the western shoreline of Black Bay in this area. Development and infrastructure to access an off-shore site is limited throughout the bay.

Summary of the Net Pen Site Review

Three potential areas have been identified that may be suitable for the establishment of net-pen aquaculture sites between Victoria Island and Copper Island, along the north shore of Lake Superior. In order of suitability, they are Nipigon Bay, Victoria Islands and Black Bay. Preliminary evaluations were based on suitable water depths and shelter from prevailing winds. In general, environmental factors are favourable at all three sites, while the need to establish shoreline infrastructure to service either on-shore or off-shore sites is required at all locations.

The Thunder Bay area was deemed to not be suitable due to exposure to predominant winds, shoreline development, municipal infrastructure and adjacent to Sleeping Giant Provincial Park along the section of undeveloped shoreline.

Lake Huron vs Lake Superior

As previously stated, Ontario farms produced more than 7,000 tonnes of rainbow trout. Lake-based, net pen production accounts for 85% of the total production and is mainly located in Lake Huron, with most operations centred in the North Channel area near Manitoulin Island. This area has some advantages as well as some challenges.

Advantages

- Seven companies have operated twelve net-pen culture sites in Lake Huron for many years.
- The supply chain for key inputs such as fingerlings, feed, & processing services is well established
- The existing workforce is experienced
- There are productive relationships with neighbouring First Nations communities
- The regulatory process is reasonably well defined

Challenges

- Summer water temperatures are routinely too warm for optimal growth of the inventory.
- Access to new sites to expand production capacity has been difficult
- The supply of juveniles is based largely in southern Ontario (distance, capacity)
- User group conflict remains unresolved
- The industry is very consolidated making it difficult for new entrants in this area

The opportunity to explore Lake Superior for the production of rainbow trout presents also presents some advantages and challenges.

Advantages

- Opportunity to establish a long-term plan for the strategic development of sustainable aquaculture production based on the Lake Huron experience (+30 years).
- There are potential areas available for aquaculture development
- Summer water temperatures are ideal for optimal growth of the inventory
- Developed commercial infrastructure (roads, rail, ports, industrial parks) is available in the region
- Neighboring First Nations communities may be interested in this opportunity

Challenges

- MNRF has previously expressed concern about net-pen aquaculture development in Lake Superior – presumably because of opposition from the US states
- The supply chain for key inputs such as fingerlings, feed, & processing services is not established

- The supply of juveniles is likely going to based largely in southern Ontario (distance, capacity)
- A technically trained workforce is not readily available

2.5 Potential Seafood Markets

The scope of this report does not include an in-depth evaluation of specific markets for each potential species that might be farmed in the Thunder Bay area. It does provide an overview of the availability of potential markets and specific references where additional information may be obtained (see Appendix B). Within a 15-hour drive from Thunder Bay, there are 9 to 10 Million potential seafood consumers (Table 15).

Figure 6: Map of a 1500 km (by road) catchment area around Thunder Bay, ON (adapted from Google Maps)

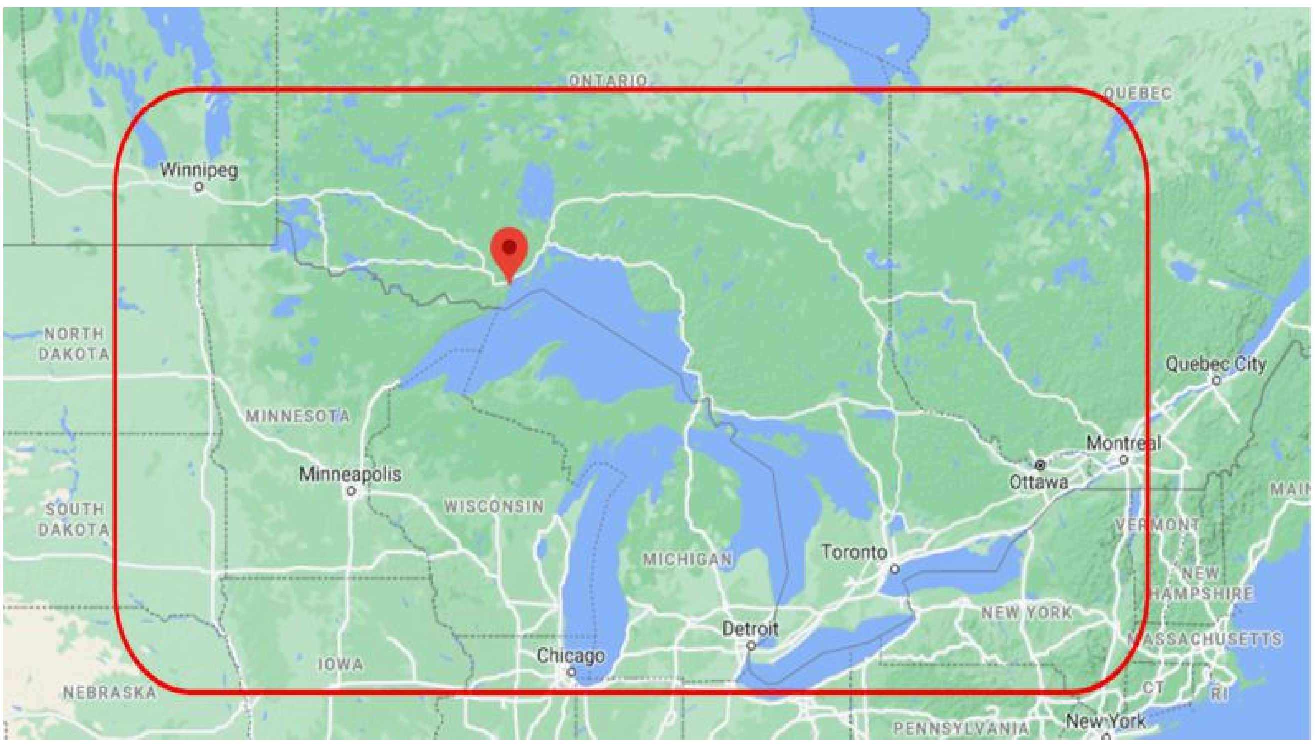

Table 15: Distance to Major Urban Centres

	Population	Distance	Travel
Winnipeg	700	700 kms	8 hrs
Minneapolis	380	550 kms	6 hrs
Chicago	2,700	1050 kms	11 hrs
Detroit	700	1300 kms	13 hrs
Toronto	2,700	1400 kms	15 hrs
Montreal	1,700	1600 kms	18 hrs
(x 1000)	9,000		

The average consumption of seafood in North America is approximately 7.1 kilograms (all species) per capita compared to global per capita consumption of 20.4 kilograms (see Table 1). The National Fisheries Institute (USA) tracks the consumption per capita in the US and estimates that the top ten species consumed (by volume) represent about 84% of all seafood consumed. It also notes that seafood consumption in the third largest seafood market in the world is not as popular as meat. American households purchase fresh seafood about 4.3 times per year compared to 27 purchases of meat. The top 10 species of seafood consumed are outlined in Table 16. Notably, salmon, tilapia, pangasius, and catfish are predominantly produced via aquaculture.

Table 16: Top Ten Seafood Species Consumed in North America

Consumption per Capita	Lbs	Kilos
Shrimp (all forms)	4.4	2.00
Salmon	2.41	1.09
Canned Tuna	2.1	0.95
Tilapia	1.08	0.49
Alaska Pollock	0.78	0.35
Pangasius	0.71	0.32
Cod	0.66	0.30
Crab	0.52	0.24
Catfish	0.53	0.24
Clams	0.31	0.14
All Other	2.15	0.98
	15.65	7.10

Using the consumption per capita statistics and the population estimate for the catchment area, the total available seafood market should equate to approximately 64 M kilos of seafood per annum.

Specific information concerning the consumption per capita of freshwater fishes from Northern Ontario is difficult to come by, however, some of the primary resources available for more information would be companies such as Presteve (ON)[30], John O Foods (ON)[31] and the Freshwater Fish Marketing Corporation (FFMC) based out of Winnipeg, Manitoba[32].

The consumption for all salmonids (salmon, trout, charr) in North America is estimated to be 1.4 kilos[33]. Using this consumption per capita statistic and the population estimate for the catchment area, the total available salmonid seafood market should equate to approximately 12.6 million kilos per annum.

Key Market Drivers

- Growth in seafood production is limited by stagnating wild catch, while the contribution of aquaculture to global fish production is projected to continue to grow and to surpass that of total capture fisheries by 2024.
- Demand is stimulated by changes in dietary trends and a greater focus on health, with fish playing a key role in this regard.
- The largest markets in North America are heavily dependent on imports to meet customer demand. 98% of the Atlantic salmon consumed in the US is imported, with Chile, Canada and Norway being the top three suppliers.
- The Kontali report, Salmon World 2020, has estimated that salmon consumption in the US has increased 9% between 2011 and 2018 – increasing the demand by 200,000 kilos per annum. The market continues to be under-supplied.
- Consumption per capita of salmonids in the US is 1.4 kilos while an equivalent consumption per capita in Germany and France is 2.4 kilos. In Sweden and Norway, it is over 6.0 kilos.

Typical Distribution Process Flow

Salmonids generally have strong market acceptance due to the firm texture and mild flavour. 80% of the supply is consumed fresh and it has a strong recognition by consumers. 60% or more of the consumption of seafood is done in HORECA[34]. Most of the imported rainbow trout has been sold in retail.

Buyers can include one or more of the following

- Whole Fish buyers - processors, distributors
- Live Buyers - limited to large urban centres
- HORECA - (formerly referred to as HRI)
- Distributors - national and regional

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[30] https://presteve.com/
[31] https://johnofoods.com
[32] Freshwaterfish.com
[33] Kontali: Salmon World 2020 and Salmon Market Analysis 2018
[34] HORECA- The hospitality industry is a broad category of fields within the service industry that includes lodging, food and drink service, event planning, theme parks, and transportation. It includes hotels, restaurants and cafes.

- Retail - sell directly to the large regional grocery store
- Large Buyers – typically requires programmed sales
- Kosher/Sushi - specialized product formats

Rainbow Trout Market (notes)[35]

Trout is widely recognized as a highly desirable fish by most North American consumers. While *per capita* consumption of seafood, in general, has been increasing over the past decade (driven by population growth and favourable demographics – an ageing population and increased affluence), trout consumption rates have remained relatively stable –due to the shortage of supplies. The North American market for rainbow trout is domestic supply-limited. The Ontario trout market is also supply limited, with Ontario-produced trout account for only 40% of the total demand. The balance of the product is imported, predominantly from Peru and Chile.

Historically, rainbow trout produced in Ontario have been harvested at an average weight of 1 to 1½ kilograms, a size that is favourable to production in open-water net-pen operations. Over the last several years, however, the North American trout market has evolved toward larger fish. An average harvest weight of 1.8 to 2.7 kg (4-6 lbs) is now preferable. Larger fish yield larger fillets, which provide versatility and enhanced opportunities for processors to produce various-sized portions and other value-added products. As a result, larger trout command a premium price.

A well-managed land-based and/or lake-based facility will be capable of producing large trout for a higher-end market and will be able to assure the size and quality of harvest fish every week. Consistency of supply (quantity & quality) 52-weeks per year remains an issue within the Ontario open net-pen industry.

There are 3 principal processors in Ontario and Quebec which have the infrastructure available for supplying the harvesting containers and ice, trucking and processing. It would be advantageous, at least initially, to work with one or more of these companies. The market presence of an established processor/distributor will facilitate the movement of trout supply into the market without cannibalizing sales from other ventures, enabling the product to enter the market in an orderly manner and realizing the best possible farm-gate price.

The largest trout processor in Canada is Cole-Munro Foods Group in St. Thomas, ON. Currently, volumes are approaching 5,000 tonnes annually but the plant throughput has twice this capacity. While the main food retailers continue to be a strong part of Cole-Munro's business, the big box store business is growing substantially.

[35] T Drost – 4 Links Marketing: Personal Communication

3.0 SWOT ANALYSIS

The SWOT acronym refers to the Strengths, Weaknesses, Opportunities, and Threats involved in a project. Strengths and weaknesses are internal considerations for which means to impose control and direction can be potentially developed. Opportunities and threats, however, are factors that are external to the project but which must, nevertheless, be considered in the planning and development process since they have a real capacity to influence success or failure.

A STEEP [36] analysis is a tool to evaluate various external factors impacting an organization. STEEP is an acronym for Social, Technological, Economic, Environmental, Political factors. The result is robust, strategic tool that requires reflection on a broad range of considerations that can influence the success of a project. These are standard Enterprise Planning System assessment tools for stakeholders to provide input as well become informed about the planning process

When conducted thoroughly, a SWOT analysis will reveal key strengths to build upon and opportunities to exploit while simultaneously focusing attention on those areas where improvement is necessary and where external factors may impose additional constraints to be addressed. In short, this approach guides the compilation of necessary information in a way that enables the development of structured responses to resolve underlying critical issues that must be addressed to generate the intended results.

For this review, the SWOT/STEEP tables were populated with the data that was derived from multiple sources and are found in Appendix C. The outcome of the first part of the process was to develop an understanding of the aquaculture sector as a whole and within the key functional areas of Market Factors, Technological & Production Factors, Socio-Political, Regulatory and Environmental Factors as well the Economic Factors.

The outcome of the second part of the process, was to ask some key questions by the functional area (using the Horizontal and Vertical Causal analysis), driving towards a prioritized summary of key problems that need to be addressed. The final output is based on a weighting of occurrence indicating the strategic areas that, if implemented, can effect meaningful change.

Summary of the SWOT Analysis

Three species of finfish could be used to develop an aquaculture sector in the Thunder Bay area. Rainbow trout appears to be the one that is likely to be the most economically viable.

Both land-based and lake-based opportunities could be further explored as the preliminary evaluations indicate that the environmental factors are favourable for development.

The high priority and important issues could be resolved by working with First Nations communities to foster aquaculture development in the Thunder Bay Region.

[36] STEEP Analysis is a tool to evaluate various external factors impacting an organization. STEEP is an acronym for Social, Technological, Economic, Environmental, Political factors.

4.0 CAPITAL REQUIREMENTS FOR AQUACULTURE SYSTEMS

The current literature has multiple examples of comparative economics for land-based and net pen-based systems. These comparisons are useful for providing general guidance however the construction and operating costs of aquaculture ventures are site-specific, and caution is advised when using these data. Actual *pro forma* financial statements based on supplier quotes and local conditions should be prepared for proper evaluation. All of the financial numbers presented are in $ CDN dollars

4.1 Land-Based Scenario

A production plan is presented as a means of illustrating the scope of the investment required for an annual production of 250 MT's. The land-based system is based on high-intensity RAS technology and the culture of rainbow trout. The input parameters used in the production plan are based largely on known industry standards and the experience of the authors of this report.

4.1.1 Land Based RAS – Production Plan

Using standard fish culture modelling, the conceptual production plan for this venture assumes an average harvest weight of +2,000 grams per fish. The fish will be raised in a concrete raceway system, harvested and be sold at fob the facility as whole fish to fish processors.

Table 17: Production summary for the aquaculture venture.

Land Based - 250 mt Aquaculture Venture
Production Plan Summary

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Year	**1**													
Fingerlings		32,100	0	0	32,100	0	0	32,100	0	0	32,100	0	0	
Biomass	(kg)	788	1,683	3,079	5,879	9,503	14,448	21,719	32,043	43,689	57,647	74,633	92,911	
Harvest	(kg)	0	0	0	0	0	0	0	0	0	0	0	0	0
Feed	(kg)	514	984	1,535	2,727	3,986	5,440	7,645	12,026	13,481	15,669	20,354	21,770	106,132
Year	**2**													
Fingerlings		32,100	0	0	32,100	0	0	32,100	0	0	32,100	0	0	
Biomass	(kg)	95,044	95,528	92,911	95,044	95,528	92,911	95,044	95,528	92,911	95,044	95,528	92,911	
Harvest	(kg)	18,420	20,895	23,077	18,420	20,895	23,077	18,420	20,895	23,077	18,420	20,895	23,077	249,567
Feed	(kg)	24,243	26,064	24,607	24,243	26,064	24,607	24,243	26,064	24,607	24,243	26,064	24,607	299,659
Year	**3**													
Fingerlings		32,100	0	0	32,100	0	0	32,100	0	0	32,100	0	0	
Biomass	(kg)	95,044	95,528	92,911	95,044	95,528	92,911	95,044	95,528	92,911	95,044	95,528	92,911	
Harvest	(kg)	18,420	20,895	23,077	18,420	20,895	23,077	18,420	20,895	23,077	18,420	20,895	23,077	249,567
Feed	(kg)	24,243	26,064	24,607	24,243	26,064	24,607	24,243	26,064	24,607	24,243	26,064	24,607	299,659

To yield a consistent harvest volume of product throughout the year, it will be necessary to stock juvenile fish into the facility four times annually at 3-month intervals. To produce the juvenile fish on-site, part of the facility will be dedicated to incubating and hatching rainbow trout eggs, which can be attained year-round from certified sources in Canada and the USA.

In the early rearing (ER) stage of the production, the trout eggs are incubated a single-stack MariSource™ [37] vertical tray incubation system. Upon hatching, the alevins (sac fry) are transferred into four 2.4-meter diameter first-feeding circular tanks (2.8 m^3 each) to be weaned onto a commercial diet. The fingerlings resulting from this stage are projected to reach an average weight of 10 grams within three months. These are then transferred into the four production raceways for on-growing to market size. Just before harvest, the fish are transferred to market conditioning tanks to improve the quality and texture of the flesh before they are processed. This is a standard procedure for freshwater RAS systems.

A feed ration has been calculated based on practical experience gained with rainbow trout in land-based facilities and reflects the following factors:

- The projected gain in biomass for each growth period
- The economical feed conversion ratio (i.e. kg feed per kg growth)
- Average FCR throughout the entire growing period = 1.20: 1

Feed distribution on the farm is mechanized to reduce labour requirements. Nevertheless, about 20% of the daily ration would be delivered by hand. The latter is necessary to enable production staff to conduct daily observations of fish behaviour. Ensuring that the rations are efficiently utilized by the fish is vital to a well-run operation.

Upon attaining steady-state production, the full length of all raceways will be in use to optimize productivity. Rearing densities are projected to be below 40 kg/m^3 in the fingerling production system and 70 kg/m^3 in the raceways. These rearing densities are within acceptable industry norms for rainbow trout raised in RAS systems.

Experience suggests that around 65% of all eyed eggs stocked into the facility will be harvested as a marketable product. The bio-programming projections reflect mortalities of 29% during the incubation stage plus additional losses of 8% throughout the rearing period. The harvest plan projects a yield of approximately 18,000 to 23,000 kilograms of whole fish (round weight) available to sell every month at an average weight of 2.2 kilograms.

[37] http://www.marisource.com/index.php/marisource-8-tray-vertical-incubator-for-trout.html

4.1.2 Land Based RAS – Financial Summary

Financial projections indicate that a total investment of $5,650,000 would be required to establish this scale of aquaculture venture. Of this, $4,220,000 is needed to finance capital equipment such as the building, fish tanks, water filtration equipment, circulating pumps, fish culture equipment and building infrastructure (Table 18 & 19).

An additional $1,430000 is required for working capital to finance the purchase of eggs and feed, and to cover labour, utilities and other operating expenses until there is sufficient operating cash flow to cover these expenses. It is common practice in the aquaculture sector to report project development costs in terms of the cost per metric tonne.

Table 18: Total Investment for the land-based RAS aquaculture venture.

Investment	Total	$/tonne
Working Capital	$ 1,430,000	$ 5,730
Fixed Capital	$ 4,220,000	$ 16,909
Total Investment	$ 5,650,000	$ 22,639

Table 19: Capital budget for the land-based RAS aquaculture venture.

Capital Budget	
Infrastructure	$ 2,000,000
Raceways, Troughs & Purge Tanks	$ 625,000
Water Reconditioning System	$ 1,300,000
Fish Culture Equipment	$ 95,000
Other Equipment	$ 200,000
TOTAL	$ 4,220,000

Due to the frequent stocking schedule and rapid growth rate of the trout, the venture quickly achieves a routine level of production. Steady-state operations are attained in the second year of operations when the continuous weekly harvest of ~4,800 kilograms of whole trout begins. The principal operating inputs for the venture are presented in Table 20

Table 20: Financial inputs for the land-based RAS aquaculture venture.

PRODUCTION			
Annual Output (tonnes whole fish)	250		
Cost of Feed	$2,000/tonne (delivered)		
Feed Conversion Ratio	1.20 kg feed per kg gain (overall average)		
Cost of Eyed Eggs	$100/1,000 eggs (delivered)		
Survival	63% of eggs become harvested fish		
Labour	3 fulltime Fish Technicians @ $20.00/hr		
Site Supervisor	1 Full-time @ $ 35.00/hr		
Maintenance & Repairs	$0.09/ kg biomass		
Supplies	$0.09/ kg biomass		
Electrical Demand	123 kW		
Cost of Electricity	$0.125/kWhr		
FINANCE & INVESTMENT			
Selling Price of Fish	$7.05/ kg farm gate, round ($ 3.20/ Lb)		
Equity Financing	$	550,000	10%
Debt Financing (8%/120 mo's)	$	4,600,000	81%
Development Grant	$	500,000	9%
Total Captialization	$	5,650,000	100%

Note: This scenario assumes that a 10% Equity investment is sufficient to satisfy any lending covenants. It also assumes that the facility would be able to access a Development Grant for new CapEx projects in Northern Ontario. It does not take into account any other types of financing that may be available nor does it not include any costs associated with obtaining an Aquaculture licence.

When the venture is operating at a steady state, the direct cost of production of fish works out to $3.79 per kilogram, with indirect costs (e.g. depreciation, interest, insurance, vehicle and administrative expenses, etc.) adding $2.64 / kg. The total cost of production is $ 6.43 per kilogram. Figure 7 outlines in the form of a graph the major costs centers. (direct and indirect).

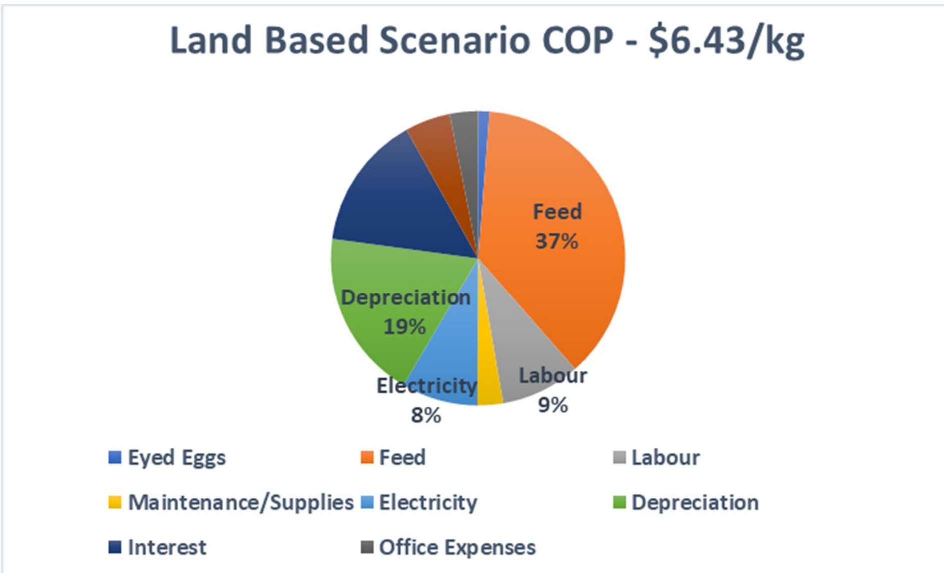
The sale of 250 tonnes of trout annually at a farm-gate price of $7.05 / kg would yield a net return of $0.62 / kg or about $155,000 per year. Trailing EBITDA (earnings before interest, tax, depreciation and amortization[38]) is projected to be over 25% after five years of operation.

It is important to note that the economic scenario presented herein is sensitive to changes in the principal assumptions. Most notably, should input costs increase (e.g., expenses associated with feed, labour, direct supplies and/or services) or output and/or revenue decrease (e.g. greater mortality, slower growth,

[38] Earnings Before Interest Tax Depreciation Amortization (EBITDA) provides a way to evaluate the performance of a venture without having to factor in financing decisions, accounting decisions or tax environments. It enables the comparison of a venture with its competitors or peers across regions.

lower selling price) then profitability can be expected to decline accordingly. The inverse is also true; that is lower input costs and higher selling prices will increase profitability. Experience suggests that changes in feed costs, growth rates, survival to market and selling price impart the greatest leverage on operating margins.

Figure 7: Total Cost of Production by Major Category



4.2 Lake Based Scenario

As with the land-based scenario, a lake-based scenario using net pens is presented as a means of illustrating the scope of the investment required for an annual production of 250 MT's. The let pen system is based on using steel cages (as per the current industry in Lake Huron) and the culture of rainbow trout. The input parameters used in the production plan are based largely on known industry standards and the experience of the authors of this report.

4.2.1 Lake Based Net Pen – Production Plan

Using standard fish culture modelling, the conceptual production plan for this venture assumes an average harvest weight of +2,000 grams per fish (Table 21). The fish will be raised in a net pen system, harvested and sold fob the facility as whole fish to fish processors.

The net pen systems rely on the ambient water temperatures and make a consistent harvest volume of product throughout the year more challenging. This can be accomplished by using multiple grow-out sites with offset stocking strategies, as these systems are usually stocked only once annually. Rainbow trout juveniles can be attained year-round from certified sources in Canada.

Table 21: Production summary for the aquaculture venture.

Net Pen - 250 mt Aquaculture Venture
Production Plan Summary

MONTH	1	2	3	4	5	6	7	8	9	10	11	12	Total
YEAR 1													
FISH INTRO	149,500				0								149,500
BIOMASS (kg)	21,304	34,619	60,818	72,772	97,250	146,134	201,284	189,135	157,098	86,382	0	0	1,066,795
HARVEST (kg)	0	0	0	0	0	0	0	47,500	40,000	70,700	91,942	0	250,142
FEED (kg)	8,895	15,978	23,579	17,931	34,269	56,217	77,210	44,188	17,918	0	11,119	0	307,304
YEAR 2													
FISH INTRO	149,500				0								149,500
BIOMASS (kg)	21,304	34,619	60,818	72,772	97,250	146,134	201,284	189,135	157,098	86,382	0	0	1,066,795
HARVEST (kg)	0	0	0	0	0	0	0	47,500	40,000	70,700	91,942	0	250,142
FEED (kg)	8,895	15,978	23,579	17,931	34,269	56,217	77,210	44,188	17,918	0	11,119	0	307,304
YEAR 3													
FISH INTRO	149,500				0								149,500
BIOMASS (kg)	21,304	34,619	60,818	72,772	97,250	146,134	201,284	189,135	157,098	86,382	0	0	1,066,795
HARVEST (kg)	0	0	0	0	0	0	0	47,500	40,000	70,700	91,942	0	250,142
FEED (kg)	8,895	15,978	23,579	17,931	34,269	56,217	77,210	44,188	17,918	0	11,119	0	307,304

Under this scenario, 149,500 juvenile trout, with a minimum average weight of 150 gms each, would be purchased each Spring and transferred into the six net pens for on-growing to market size. Fish would be fed a feed ration based on diets that are commercially available and used with rainbow trout farming in net pen systems at other locations

Feed distribution on the farm is done manually and with the assistance of mechanized blowers and underwater camera systems to reduce labour requirements and to allow the staff to conduct daily observations of fish behaviour. One principal difference between land-based tank systems and net-pen systems is that the ability to observe the swimming inventory in net pens is restricted by the depth of the net pens. Ensuring that the rations are efficiently utilized by the fish is vital to a well-run operation.

Upon attaining steady-state production, all the net pens will be in use to optimize productivity. Rearing densities are projected to be below 20 kg/m^3. These rearing densities are within acceptable industry norms for rainbow trout raised in freshwater net-pen systems.

Experience suggests that around 80% of all juvenile trout (fingerlings) stocked into the facility will be harvested as a marketable product. The harvest plan projects a yield of approximately 48,000 to 90,000 kilograms of whole fish (round weight) available to sell over a four-month period at an average weight of 2.0 kilograms.

4.2.2 Lake Based Net Pen – Financial Summary

Financial projections indicate that a total investment of $2,000,000 is required to establish this scale of aquaculture venture. Of this, $673,500 is required to finance capital equipment such as the cage and net pen systems, boats, and fish culture equipment. (Table 22 & 23).

An additional $1,326,500 is required for working capital to finance the purchase of juveniles and feed, and to cover labour, and other operating expenses until there is sufficient operating cash flow to cover these expenses.

Table 22: Capital budget for the net-pen aquaculture venture.

Investment	Total	$/tonne
Working Capital	$ 1,326,500	$ 5,303
Fixed Capital	$ 673,500	$ 2,692
Total Investment	$ 2,000,000	$ 7,995

Table 23: Capital budget for the lake based net-pen aquaculture venture.

Capital Budget	
Cage Systems, Mooring & Net Pens	$ 399,000
Boats, barges	$ 100,000
Fish Culture Equipment	$ 72,500
Other	$ 102,000
Total	$ 673,500

Due to the annual stocking schedule and rapid growth rate of the trout, the venture achieves a routine level of production. Steady-state operations are attained in the second year of operations. The principal operating inputs for the venture are presented in Table 24

Table 24: Financial inputs for the lake-based net-pen aquaculture venture.

PRODUCTION			
Annual Output (tonnes whole fish)	250		
Cost of Feed	$2,100/tonne (delivered)		
Feed Conversion Ratio	1.25 kg feed per kg gain (overall average)		
Cost of Fingerlings	$ 2.00/unit delivered		
Survival	80% of fingerlings become harvested fish		
Labour	3 fulltime Fish Technicians @ $20.00/hr		
Site Supervisor	1 Full-time @ $ 30.00/hr		
Diving Services (outsourced)	75.00/hr		
Maintenance & Repairs	$0.05/ kg biomass		
Supplies	$0.18/ kg biomass		
FINANCE & INVESTMENT			
Selling Price of Fish	$7.05/ kg farm gate, round ($ 3.20/ Lb)		
Equity Financing	$	200,000	10%
Debt Financing (8%/84 mo's)	$	1,550,000	78%
Development Grant	$	250,000	13%
Total Captialization	$	2,000,000	100%

Note: This scenario assumes that a 10% Equity investment is sufficient to satisfy any lending covenants. It also assumes that the facility would be able to access a Development Grant for new CapEx projects in Northern Ontario. It does not take into account any other types of financing that may be available, nor does it not include any costs associated with obtaining an Aquaculture licence.

When the venture is operating at a steady state, the direct cost of production of fish works out to $4.55 per kilogram, with indirect costs (e.g. depreciation, interest, insurance, vehicle and administrative expenses, etc.) adding $1.02/ kg. The total cost of production is $ 5.57 per kilogram. Figure 8 outlines in the form of a graph the major costs centers. (direct and indirect).

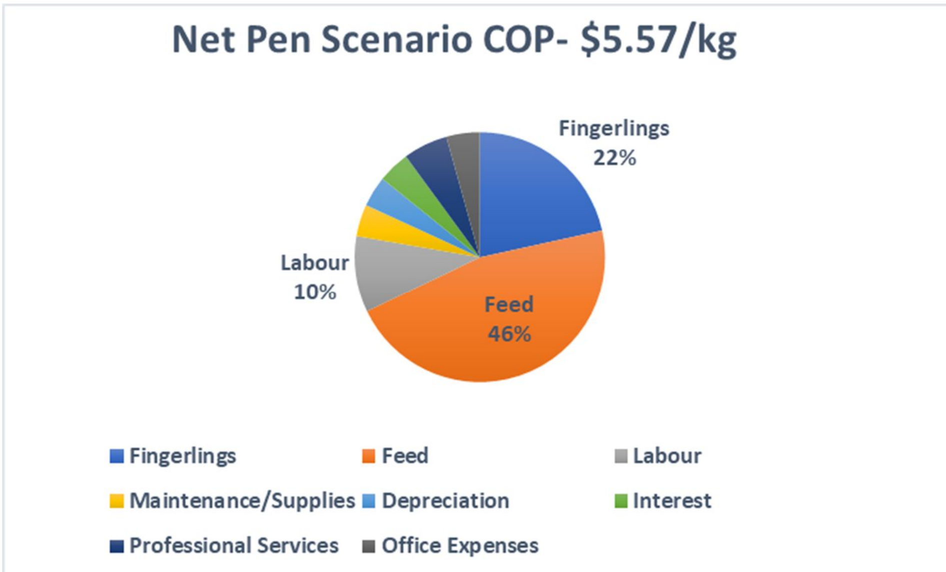
The sale of 250 tonnes of trout annually at a farm-gate price of $7.05 / kg would yield a net return of $0.1.03 / kg or about $250,000 per year. Trailing EBITDA (earnings before interest, tax, depreciation and amortization[39]) is projected to be over 25% after five years of operation.

It is important to note that the economic scenario presented herein is sensitive to changes in the principal assumptions. Most notably, there is no cost allocated to the development of a lake-based aquaculture lease. Also, should input costs increase (e.g., expenses associated with feed, labour, direct supplies and/or services) or output and/or revenue decrease (e.g. greater mortality, slower growth, lower selling

[39] Earnings Before Interest Tax Depreciation Amortization (EBITDA) provides a way to evaluate the performance of a venture without having to factor in financing decisions, accounting decisions or tax environments. It enables the comparison of a venture with its competitors or peers across regions.

price) then profitability can be expected to decline accordingly. The inverse is also true; that is lower input costs and higher selling prices will increase profitability. Experience suggests that changes in feed costs, growth rates, survival to market and selling price impart the greatest leverage on operating margins.

Figure 8: Total Cost of Production by Major Category



5.0 POTENTIAL BUSINESS PARTNERSHIPS

In a recent article (23 Nov 2020) in Undercurrent News®[40], well respected international publication that reports on the Fisheries and Aquaculture Sectors worldwide, Dan Gibson summarized the "Window of Opportunity" surrounding the 2020 aquaculture stock placement boom that the investment markets have been experiencing. Seven different aquaculture companies have raised (when combined) over $ 400 million in new equity – with more to come.

Rabobank seafood analyst Gorjan Nikolik notes that recirculating aquaculture systems (RAS) in particular are seen by investors as being beyond a safe bet. He notes that "generally the food industry novel technologies and RAS are seen as a thing beyond the pandemic and a good place to put your capital".

Birgir Brynjolfsson, from the seafood advisory firm Antarctica Advisors, added that the habits gained during the pandemic, such as cooking more seafood at home and the explosion of online trade, will have a long-term effect on the industry. "All this makes 2021 a year to look forward to."

First Nations Communities

Also noted was the growing prevalence of First Nations communities making major seafood transactions. Three deals, in particular, were noted: Bristol Bay Native Corporation's acquisition of *Blue North Clipper*, Sealaska's purchase of a majority stake in the UK processor *New England Seafood International* and the recent involvement of the Membertou and Miaopukek First Nations in the acquisition of *Clearwater Seafoods* on the East Coast of Canada. These transactions highlight the growing involvement of First Nations in the seafood industry.

Nikolik and Brynjofsson conclude by stating that whether they're in Canada or elsewhere, these investments provide for a very good marketing story when these groups invest in this kind of primary production.

Canada

Canada's Blue Economy Strategy 2040[41] co-authored by the Canadian Aquaculture Industry Alliance and the Fisheries Council of Canada, was developed in part because other nations, including the UK, Australia, New Zealand and Norway have all developed multi-year plans to sustainably develop their seafood opportunity, grow jobs and develop their leadership. These integrated plans and actions have resulted in positive change and the realization of greater value.

The Vision for the outlined strategy focusses on three key growth targets:

1. Double the Value of Canadian Seafood
2. Double the Economic Benefits resulting from the Fisheries and Aquaculture Sectors
3. Double domestic consumption of fish and seafood

[40] Undercurrent News- https://www.undercurrentnews.com

[41] Canadian Aquaculture Industry Alliance; Fisheries Council of Canada | The Voice of Canada's Commercial Fishing Industry

5.1 Partial Listing of Equity Investors

What follows is a list of potential equity investment partners for an aquaculture venture. The list is not meant to be comprehensive but illustrates the growing interest by investment instruments in the sector

Table 25: Partial List of potential sources of Equity Investment.

Potential Equity Investment Partners - w/Interest in Aquaculture				
AlphaNorth Asset Management	Toronto	ON	Can	https://www.alphanorthassets.com
Artemis Investment Management Limited	Toronto	ON	Can	https://www.artemisfunds.ca
Beacon Securities Limited	Toronto	ON	Can	https://www.beaconsecurities.ca
Dundee Corporation	Toronto	ON	Can	http://dundeecorp.com
Echolon Wealth Partners	Toronto	ON	Can	https://www.echelonpartners.com
Fair Ventures (A Fairfax Company)	Toronto	ON	Can	https://www.fairfax.ca
Gravitas Financial Inc.	Toronto	ON	Can	http://gravitasfinancial.com
Kensington Capital Partners	Toronto	ON	Can	https://www.kcpl.ca
INFOR Financial Inc	Toronto	ON	Can	httpps://www.inforg.com
Ontario Teachers' Pension Plan	Toronto	ON	Can	https://www.otpp.com
STOPE CAPITAL ADVISORS INC.	Toronto	ON	Can	jfitzgerald@stopecapitaladvisors.com
InvestEco	Toronto	ON	Can	https://investeco.com
Public Sector Pension Investment Board	Montréal,	Québec	Can	https://www.investpsp.com
Business Development Bank of Canada			Can	Various locations
CAPE Fund	Montreal	Québec	Can	http://www.capefund.ca
Leede Jones Gable	Montréal,	Québec	Can	https://leedejonesgable.com/capital-marke
OrganiX Corportaion	Montréal,	Québec	Can	http://www.harpurcompanies.com
Markó Partners	Reykjavik		ICELAND	http://markopartners.com
Aqua Spark			Netherlands	https://www.aqua-spark.nl
ABG Sundal Collier	Oslo		Norway	https://www.abgsc.com
Nordea | Equity Research NO	Oslo		Norway	https://www.nordea.com
Agro American Company	Miami	Florida	USA	https://agroamerica.com
Cowen Investments Management LLC	New York	New York	USA	https://www.cowen.com
Seed2Growth Ventures	Chicago	Illinois	USA	https://www.s2gventures.com
American Investment Company	Salt Lake C	Utah	USA	craig@aicptv.com
50 private equity firms (USA) listing				https://www.inc.com/private-equity

5.2 Partial Listing Aquaculture Companies with Interest in Freshwater

What follows is a list of potential partners for an aquaculture venture in freshwater. The list is not meant to be comprehensive but identifies companies with a known interest in freshwater aquaculture ventures

Table 26: Partial List of potential partners for an aquaculture venture in freshwater.

Canadian Aquaculture Companies with interest in Freshwater		
MOWI Canada	BC,NL,NB	https://mowi.com/contact/canada-east
Grieg Seafood Canada	BC,NL	https://www.griegseafoodcanada.com/
Cermaq Canada	BC	https://www.cermaq.com
Cole Munro Foods Group Inc	ON	https://colemunro.com
Ocean Trout Canada Ltd	NB	https://oceantroutcanada.com
Cooke Aquaculture Inc	NB,NS,NL	https://www.cookeseafood.com

Table 27: Partial List of potential partners for an aquaculture venture in freshwater.

Companies with Freshwater Sales/Markerting Capabilities		
MOWI Canada	BC,NL,NB	https://mowi.com/contact/canada-east
Grieg Seafood Canada	BC,NL	https://www.griegseafoodcanada.com/
Cermaq Canada	BC	https://www.cermaq.com
4 Links Marketing	NB	https://www.4Links.ca
Cooke Aquaculture Inc	NB	https://www.cookeseafood.com
Simmer International	QE	simmer@sogetel.net
Freshwater Fish Marketing Corporation	MN	freshwaterfish.com
Presteve	ON	https://presteve.com/
Cole Munro Foods Group Inc	ON	gcole@colemunro.com
John O Foods	ON	https://johnofoods.com

6.0 SUMMARY

1. Canada generates more than $1.39 billion in farm-gate revenues and accounts for 16% of Canada's total seafood production (+/- 200 k tonnes annually). Freshwater aquaculture is a highly productive and sustainable use of aquatic resources with considerable potential for growth throughout all regions of Canada. Many rural communities have bio-physical resources and socio-economic interests to participate in freshwater aquaculture development.

2. First Nations Communities in Ontario are developing a governance framework to issue licences, leases, permits, rules and requirements for establishing aquaculture operations on First Nations' traditional lands and waters, empowering First Nations to manage their aquatic and terrestrial resources.

3. Several species were evaluated for their commercial culture potential in the Thunder Bay region. Rainbow trout scored highest; largely owing to the long-standing success associated with the commercial cultivation of the species in Canada. Other species, such as arctic charr are preferable over whitefish owing to the commercial culture status of charr and the absence of proven technologies, as yet, for whitefish.

4. There are two primary grow-out systems used in Ontario for the commercial production of aquaculture species; (a) Land-based systems, which come in a variety of shapes and sizes including freshwater ponds, raceways, and circular tanks. These systems are largely determined by the volume of water that is available and how the operators choose to use this; and, (b) Net-pen based systems, which also come in a variety of sizes. Most of the commercial net-pen production of aquaculture species is done in salt water and use high-density polyethylene (HDPE) circular pens. The environmental conditions in the Great Lakes make the use of the HDPE cages less efficient and most of the current production is done using cages made from steel pontoons.

5. A review of potential aquaculture sites has been explored in the Thunder Bay Region. Three potential areas have been identified that may be suitable for the establishment of net-pen aquaculture sites between Victoria Island/Pie Island and Copper Island, along the north shore of Lake Superior. In order of suitability, they are Nipigon Bay, Victoria Islands and Black Bay. Preliminary evaluations were based on suitable water depths and shelter from prevailing winds. In general, environmental factors are favourable at all three sites, while the need to establish shoreline infrastructure to service either on-shore or off-shore sites is required at all locations.

6. Canada's Blue Economy Strategy 2040[42] co-authored by the Canadian Aquaculture Industry Alliance and the Fisheries Council of Canada, was developed in part because other nations, including the UK, Australia, New Zealand and Norway have all developed multi-year plans to sustainably develop their seafood opportunity, grow jobs and develop their leadership. These integrated plans and actions have resulted in positive change and the realization of greater value.

[42] Canadian Aquaculture Industry Alliance; Fisheries Council of Canada | The Voice of Canada's Commercial Fishing Industry

APPENDICES

Appendix A - Preliminary Siting for Net Pen Systems- North Shore of Lake Superior

The following report provides a preliminary assessment of the suitability of waters along the North Shore of Lake Superior for the potential development of a net pen aquaculture facility. The review encompasses the shoreline from Copper Island west of Schreiber to Victoria Island south of Thunder Bay, a distance of approximately 180 km. This review looks at potential sites as to the suitability of conventional net pen operations for rearing rainbow trout using available information. It is not based on a site inspection by the author.

Summary

Three potential areas have been identified that may be suitable for the establishment of net-pen aquaculture sites between Pie Island and Copper Island, along the north shore of Lake Superior. In order of suitability, they are Nipigon Bay, Victoria Island/Pie Island and Black Bay. Preliminary evaluations were based on suitable water depths and shelter from prevailing winds. In general, environmental factors are favourable at all three sites, while the need to establish shoreline infrastructure to service either on-shore or off-shore sites is required at all locations.

Figure 9: Limit of Review Area between Victoria Island and Copper Island

The Thunder Bay area was deemed to not be suitable due to exposure to predominant winds, shoreline development, municipal infrastructure and adjacent to Sleeping Giant Provincial Park along the section of undeveloped shoreline.

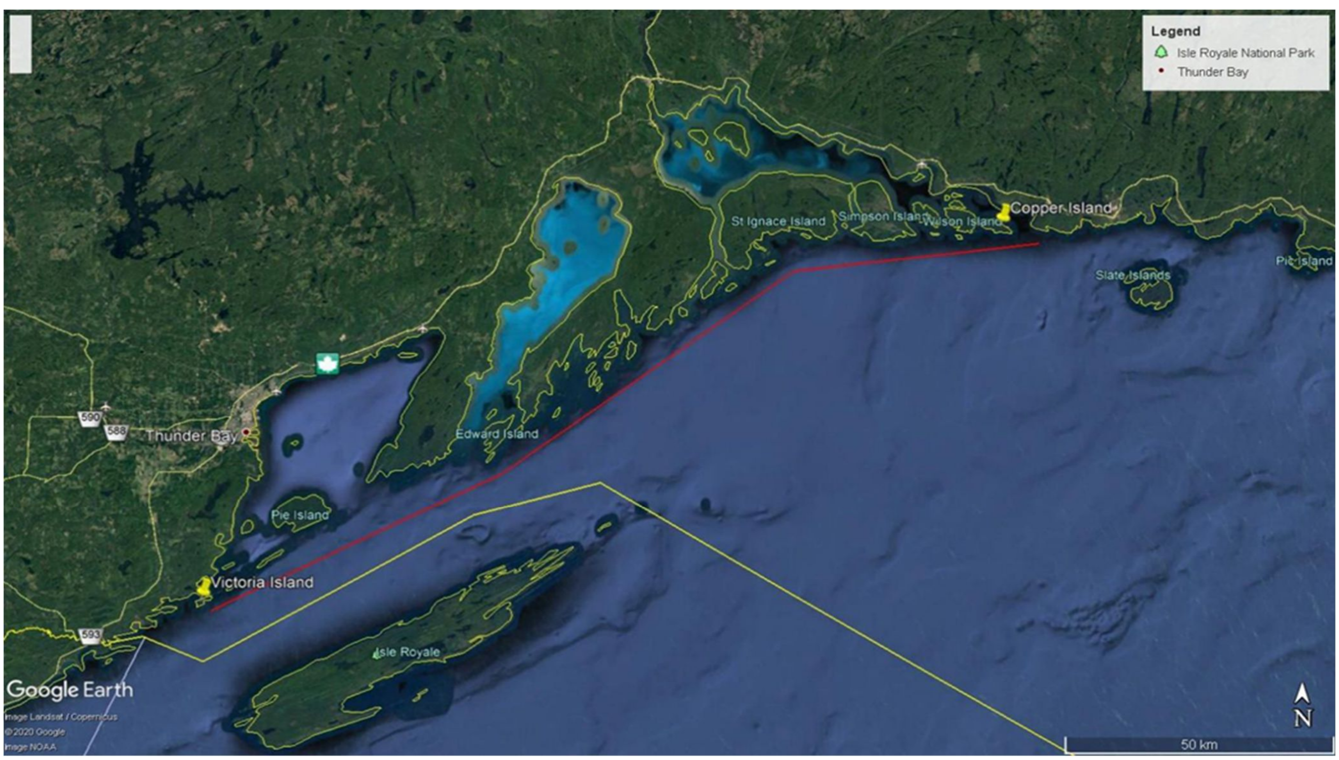
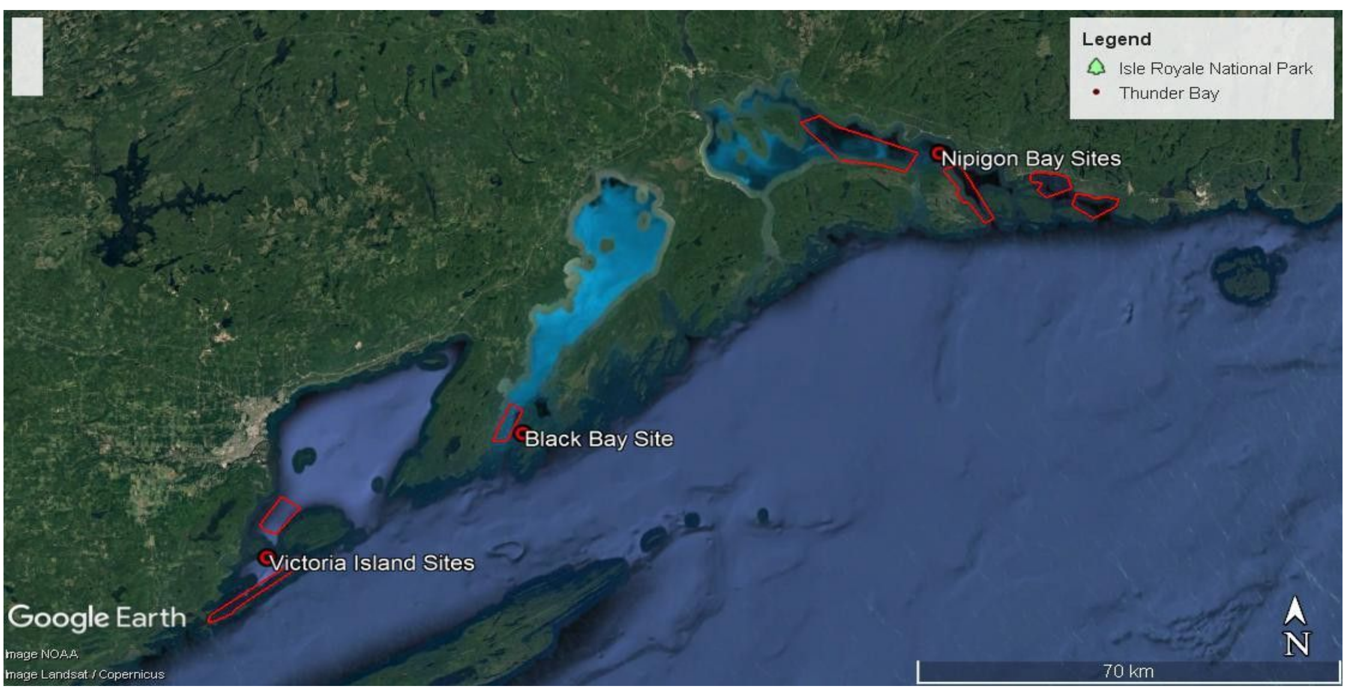


Figure 10: Potential Net pen aquaculture sites in the Nipigon Bay Area

Figure 11: Potential Net pen aquaculture site in the Black Bay area

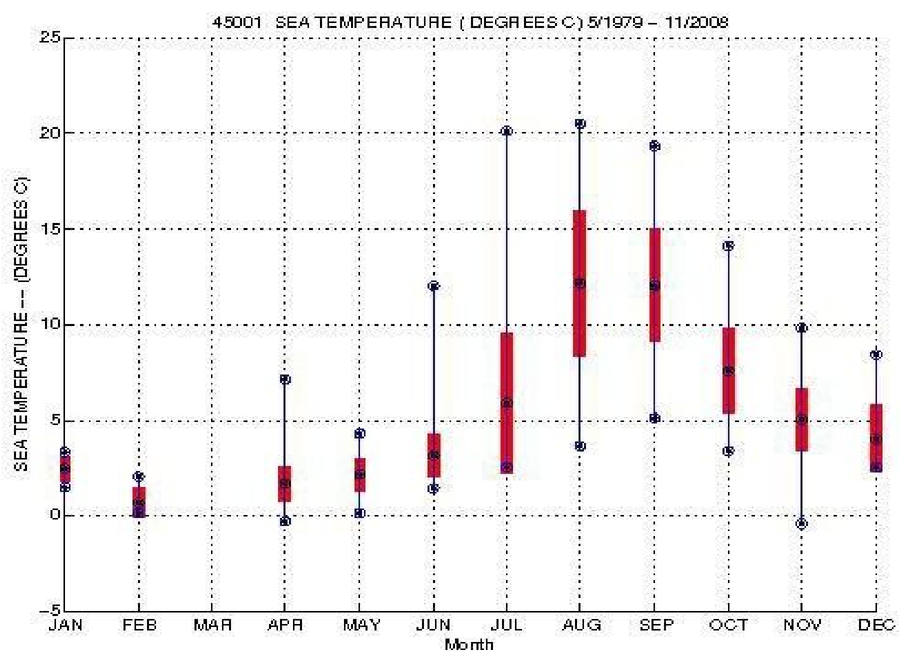
Figure 12: Potential Net pen aquaculture sites in the Pie Island -Victoria Island area

Figure 13: Overview - Potential Net pen aquaculture Sites

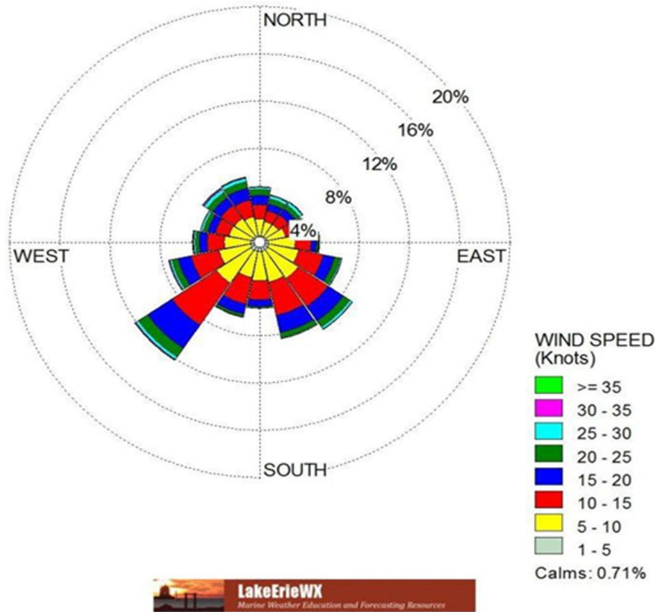


Climatology Data – Buoy 45001 Lake Superior

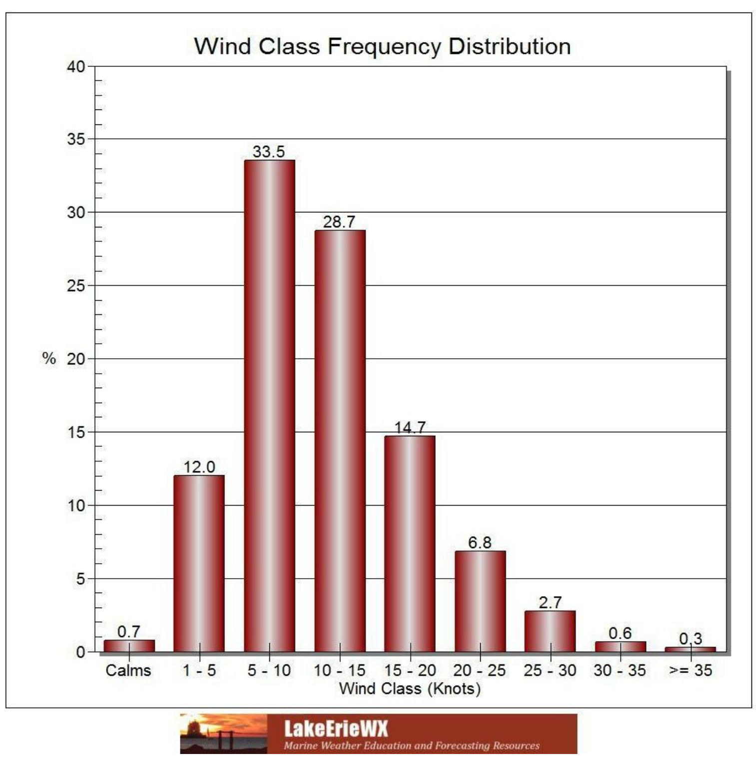
Average Lake Temperatures – Buoy 45001



Wind Rose / Direction – Buoy 45001



Wind Speed Distribution – Buoy 45001



Appendix B – Market Related Information

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Fisheries Council of Canada Conseil Canadien des Pêches Fisheries Council of Canada (FCC) is the voice of Canada's wild capture fish and seafood industry, promoting a healthy resource and prosperous industry playing a vital role in the Canadian economy. Our members include small, medium and larger-sized companies along with Indigenous enterprises that harvest and process fish from Canada's three oceans. contribute to the achievement of the Sustainable Development Goals, especially SDG 2 (Zero hunger) and SDG 14 (Life below water).

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Appendix C– S.W.O.T. Tables

AQUACULTURE SWOT-PLUS ANALYSIS – THUNDER BAY CEDC

	Market Factors
Strengths/ Positives	▪ Ontario trout has been able to compete in the served markets based on product quality and service; Ontario is not the low-cost producer. There is competition from Imports ▪ Ontario trout is capable of meeting the high service and quality standards of buyers ▪ Thunder Bay has proximity to major US markets and a reliable distribution network to service these markets as well as to service major Canadian markets in Ontario & Quebec. ▪ Trout is recognized as a healthy, quality product. It is mostly consumed fresh ▪ Most North American consumers perceive trout as a desirable fish ▪ Ontario producers are well-positioned to supply growing domestic and U.S. demand for high-quality sustainable fresh seafood. ▪ ON producers and processors abide by stringent government standards ▪ Canadian food safety standards are among the best in the world ▪ ON processors can utilize the whole fish to produce 1º and 2º products ▪ Strong trout consumption in ON and QC- retail sales are well established. ▪ North American market for trout is supply-limited ▪ Weaker $Cdn versus the $US ▪ ON producers can attain several sustainability 'certifications' to secure market access, e.g. Best Aquaculture Practices; Aquaculture Stewardship Council; Seafood Watch; Ocean Wise, etc.
Opportunities	▪ Ontario produces about 8,000 tonnes of trout yet still imports about 40% of the total demand ▪ Strong and growing demand for seafood in the United States, Canada's most important seafood market. ▪ Retailers – e.g. Costco, Wal-Mart, Supercenters, supporting large-volume sales. ▪ Increasing health concerns and positive perception of seafood as a healthy food choice. ▪ At the same time that seafood consumption has grown in the U.S., trout consumption has been flat due to a lack of consistent domestic supply. ▪ At current price levels, producers in Canada appear to have adequate margins to increase exports to the U.S. ▪ Canadian producers appear to have an advantage over Latin American producers in supplying fresh rainbow trout to the U.S. market. ▪ Based on population growth only, US demand for trout is expected to grow. ▪ Increasing the consumption per capita from 1.4 kg (all salmonids) to 2.4 kg (equivalent to France & Germany is the focus of the NA based salmon producers. Trout will benefit from this ▪ With strategic marketing/promotion, consumption could increase by more than 14,000 tonnes per year in the next decade ▪ Demand from the U.S. for high-quality fresh seafood will continue to fuel growth in Canadian aquaculture production ▪ The United States has limited opportunity for additional development of trout aquaculture due principally to conflicting policy interests ▪ Legislators in the US Great Lakes states have essentially reserved the resource for recreational and tribal fisheries to the exclusion of commercial fisheries and aquaculture ▪ The growing participation of First Nations communities in aquaculture, either as owner/operators or in partnership with non-Indigenous organizations, presents a strong opportunity to expand the sector

	▪ First Nations "certifications" will strengthen the marketability of ON aquaculture
Threats	▪ Economic uncertainty due to Covid19; particularly due to the demise of the hotels, restaurants and institutions (HRI) foodservice sector ▪ Chile, Argentina and Peru are leading exporters of trout to the US (principally frozen but some fresh) ▪ At current price levels for trout fillets, producers in Latin America also appear to have adequate margins to increase exports to the U.S. ▪ Retailers are increasingly bypassing the wholesaler-dealer to buy directly from producers. Estimates suggest that producers directly supply 25 to 35% of the products that retailers sell. ▪ Buyer power is increasing while supplier power is decreasing. ▪ Price point competition from beef, pork, poultry ▪ Capacity to protect brand (brand support, contingency planning, crisis management planning, lack of agility to respond)
Problems/ Challenges/ Weaknesses	▪ At times, insufficient product supply to meet customer demand; continuity of supply can be uncertain ▪ Inability to expand production to meet growing customer demands; will lead to loss of customers over time as supply is sourced elsewhere ▪ Sector is not large enough (product volume) to service large US retail accounts

	Technological and Production Factors
Strengths/ Positives	▪ 60+ years of experience in land-based operations and 40+ years experience in net-pen operations leading to significant experience curve effects (e.g. labour efficiency; product/process specialization, etc.) ▪ Producers are committed to support and engage in research and development initiatives to improve operations ▪ On-going development and implementation of environmentally sustainable technologies and practices ▪ Ontario has the infrastructure to support expanded production ▪ Good feed utilization and decreasing dependence on fish meals & oils ▪ ON benefits from lean manufacturing capabilities ▪ Feed quotas and TP loading criteria via feed quotas are in place ▪ Loch Lomond water supply, if developed, is a significant asset that can support more than one thousand tonnes of production in the Thunder Bay area ▪ There appear to be several potential net-pen development sites along the north shore of Lake Superior
Opportunities	▪ Plentiful biophysical resource base (i.e. water supplies, development sites) ▪ Specialized R&D capacity at U. of Guelph (Alma Aquaculture Research Station), DFO (Freshwater Institute) and Environment Canada (Centre for Inland Waters) ▪ Unlikely that US trout production will increase substantially in the future due to policy constraints and lack of adequate biophysical resources ▪ Industry experience, university and government R&D can position Ontario as a leading developer and supplier of sustainable freshwater net-pen technologies and practices ▪ Available research, development, commercialization funds to enhance technologies and practices

	▪ Expansion of net-pen aquaculture will generate opportunities for increased land-based fingerling production ▪ Advances in the productivity and economics of recirculating aquaculture systems (RAS) has increased the viability of land-based production
Threats	▪ The industry is potentially vulnerable to the Canadian Food Inspection Agency (CFIA) prohibiting the importation of new genetic material in the form of eyed-eggs ▪ Domestic trout broodstock programs are seriously underfunded and do not provide all of the desired characteristics wanted by land-based and net pen system operators.
Problems/ Challenges/ Weaknesses	▪ Limited processing capacity in the province ▪ Fingerling supply in Ontario is becoming limited ▪ Industry consolidation; the sector is dominated by one major fingerling supplier, one major net-pen producer, and one major fresh trout processor/distributor ▪ The industry is overly dependent on US supplies of eyed eggs ▪ Genetics of Ontario strains of trout need to be improved through the selection to provide a competitive advantage to domestic producers (e.g. warm water tolerance, disease resistance, improved yield, etc.) ▪ Producers are challenged by three principal diseases which impart an economic impact on rainbow trout culture in Ontario: cold water disease (*Flavobacterium psychrophilum*), columnaris disease (*Flexibacter columnaris*) and furunculosis (*Aeromonas salmonicida*) ▪ Industry-developed Codes of Practice are not widely adopted

	Socio-Political, Regulatory & Environmental Factors
Strengths/ Positives	▪ The total farm-gate value associated with land-based and freshwater net-pen aquaculture production in 2018 was approximately $30 million. Rainbow trout production accounts for >95% of the total farm-gate value. ▪ The Ontario aquaculture sector supports more than 230 full-time jobs in production, processing and the aquaculture supplies and services sector. ▪ Economic multipliers are substantial: o employment multiplier of 4.5; every job in net pen production sustains an additional 3.5 jobs in the wider economy o sales expenditure multiplier of 4; every dollar in farm gate sales generates an additional 3 dollars in the wider economy ▪ Aquaculture plays an important role in providing stable employment in small communities and rural areas of Ontario ▪ DFO's ELA research is unprecedented on a global scale and has resulted in extensive research into the Great Lakes ecosystem ▪ Due to the presence of net-pen aquaculture operations, the scope and calibre of environmental research in the Great Lakes has increased dramatically, leading to an enhanced understanding of the aquatic ecosystem ▪ Research has not discovered any long-term adverse effects of aquaculture ▪ When aquaculture sites are operated responsibly, environmental effects are usually reversible within a short time following termination of operations ▪ Credible evidence exists regarding the beneficial ecological effects of net-pen aquaculture (e.g. fisheries enhancement) ▪ Agri-food production is the largest economic sector in Ontario; considerable expertise and experience ▪ The fisheries phosphorus budget is presently negative, particularly in the upper Great Lakes

	▪ Federal and Provincial Environmental Assessment processes are in place to support informed decision-making ▪ Producers have Best Management Practices protocol developed to support effective socio-political responsibility and transparent reporting ▪ Environmental Assessment processes are intended to support informed decision-making and garner public trust
Opportunities	▪ Thunder Bay is centrally located and is the gateway to Ontario's Northwest; is extremely close (70km) to a major US border crossing, and has an extensive transportation network ▪ Ontario has a combined provincial (11.5%) and federal (15%) corporate income tax rate of 26.5% ▪ Aquaculture is a broad, horizontal file requiring effective and efficient intra-departmental and inter-departmental coordination and cooperative federal-provincial relations - which are improving ▪ Thunder Bay offers competitive land costs, construction costs, and zero development charges, making it an ideal location for expansion and new construction ▪ There is considerable interest in aquaculture development from at least three First Nations communities in the region ▪ Thunder Bay has a large amount of land zoned for new development ▪ Thunder Bay's CEDC team is available to support the development of new ventures ▪ A key element of the Thunder Bay 2019-2020 Strategic Action Plan is to "Develop and support joint projects in partnership that strengthen Indigenous communities" ▪ The city has two major educational institutions - Confederation College and Lakehead University ▪ Thunder Bay Hydro offers some of the lowest electricity rates in Ontario. ▪ There is a local initiative to revitalize the commercial fishery on Lake Superior and surrounding inland lakes and to position Thunder Bay and the processing and distribution hub. This could be complementary to aquaculture development. ▪ Aquaculture can help to enhance depleted feral fisheries populations ▪ Specialized R&D capacity at U. of Guelph and DFO – as well as on both coasts (i.e. Atlantic Veterinary College, CAT-C, Huntsman Marine Science Centre) ▪ Conduct a resource mapping exercise to identify potential regions/areas suitable for aquaculture development based on a comprehensive set of biophysical, environmental and socio-economic factors ▪ Government of Canada has created an enabling and permissive policy for expanded aquaculture development ▪ The proposed Aquaculture Act is expected to clarify currently vague policy and regulatory requirements ▪ The proposed Giigoonh Chi-Naaknigewin will empower First Nations communities to issue leases and licences for all aquaculture ventures located in traditional First Nations territories. The Giigoonh Chi-Naaknigewin has the support of the provincial and federal governments. ▪ The Province of Ontario has agreed to change from using land-use permits with insufficient duration & unacceptable termination clauses to long-term leases and to amend the 5-yr aquaculture licence term to 20 yrs to coincide with leases.
Threats	▪ Canada-US agreement on phosphorus loading to the Great Lakes Basin ▪ The net-pen aquaculture sector is prohibited from adopting technologies and practices to enhance sustainability (e.g. fallowing) ▪ Utilization of public resources (lake bed and water column) requires public value-judgement

	▪ The shared federal/provincial policy and regulatory framework governing the sector is cumbersome to implement and enforce, imposing a constraint on sectoral development outside of First Nations territories ▪ User-group conflict concerning net-pen aquaculture in public waters is often couched as 'environmental' and has been effective in curtailing industry development ▪ The current policy and regulatory framework is somewhat dysfunctional with open-ended processes and a lack of clear standards and protocols ▪ There is no dispute resolution process to appeal Provincial Government aquaculture licence decisions or conditions ▪ Expansion of net-pen aquaculture is constrained by the ardent opposition of environmental and other specific interest groups (e.g. foreshore landowners). ▪ Public opinion regarding the environmental effects of aquaculture is shaped largely by media reports of west coast salmon farming issues ▪ There is a policy vacuum regarding net-pen aquaculture in Ontario creating a situation that enables the province to do nothing ▪ Inability to access new net-pen culture production sites is the single largest constraint to industry expansion in Ontario; the site allocation process is ill-defined, cumbersome, lengthy and expensive for all parties. ▪ There are no service standards for approvals required from the government; government timelines are not reflective of business cycles in the sector ▪ Security of site tenure (Land Use Permits) is insufficient to enable producers to acquire conventional financing for fixed or operating capital / The provincial Aquaculture Licence (5-year term) is not in line with business cycles in the sector given the level of investment and the multi-year production cycle (the province has agreed to change this to 20-year licences but the change has not yet been implemented) ▪ Research results are not widely known outside the aquaculture community ▪ Insufficient research into the social aspects of aquaculture development ▪ The sector is frequently subject to capricious investigations intended to curtail net-pen culture operations in the province ▪ The provincial government notes a difference between ecological and environmental effects (i.e. an ecological benefit is still an environmental effect) ▪ A wide range of opinions exists amongst fisheries biologists and managers regarding competition from escaped rainbow trout in ON waters ▪ Insufficient ecological understanding regarding invasive species ▪ Costs associated with amending an Environmental Compliance Authorization for land-based aquaculture operations preclude changes to upgrade effluent treatment systems ▪ Aquaculture is the only agri-food sector in ON not covered by the Nutrition Management Act and Nutrient Management Plans ▪ Unresolved Land Claims – Gov't of ON is deferring any decisions
Problems/ Challenges/ Weaknesses	▪ Insufficient social research and input from communities, First Nations, etc. to adequately reflect public interests in decision-making ▪ Limited fish health management options ▪ Industry-developed Codes of Practice have not been widely adopted in the sector ▪ The sector has not established effective and on-going channels of communications with the community and public interests, both regionally, provincially and elsewhere ▪ Insufficient attention to social and socio-economic aspects of aquaculture development ▪ Most research capabilities in the sector are technical and natural-sciences oriented; social scientists/researchers have not been effectively engaged to study the sector ▪ No formal vision to research and/or support other modes of production besides net-pen culture (e.g. large-scale pump-ashore facilities, bag systems, etc.) ▪ The protocol for site applications and approvals is encumbered by a lack of policy resulting in conflicting provincial and district decisions

	▪ Reliance on imported rainbow trout eggs presents a risk of introducing a novel pathogen (aquatic animal health screening is not perfect)

	Economic Factors
Strengths/ Positives	▪ The concentration of processing capacity within the sector enhances competitiveness ▪ Affordable land-use permits/leases ▪ Net pen and land-based production of trout is profitable when designed and managed properly
Opportunities	▪ Ontario has excellent infrastructure for support services, etc. ▪ Ontario has a stable aquaculture supplier network; e.g. feed, consumables, processing/packaging materials and supplies, etc. ▪ Specialized R&D capacity to enhance profitability and competitiveness ▪ The Canadian dollar vis-à-vis the US dollar makes export opportunities more attractive ▪ It is unlikely that US trout production will increase rapidly in the future due to lack of additional water in Idaho Competitiveness can be enhanced through economies of scale; e.g. labour efficiency, work/product specialization, buyer power, etc.
Threats	▪ Inability to expand the sector (industry cannot gain access to new sites) ▪ Ontario is moving toward implementation of 'fair market value' for resource-use ▪ Expanded aquaculture development in the US and internationally ▪ Expanding marine net-pen culture production of trout in Atlantic Canada and South America ▪ Increased competition from international suppliers, e.g. trout from S. America – even with modest growth, Ontario trout producers are losing market share ▪ Increased buyer power of foodservice and retail players. ▪ There is no dispute resolution process to appeal Provincial Government aquaculture licence conditions ▪ Barriers to entry/expansion are significant - especially inability to access sites and capital ▪ No access to safety net programs that are commonly available to other agriculture producers (e.g. crop insurance, income stabilization, supply management, investment incentives, etc.)
Problems/ Challenges/ Weaknesses	▪ Industry-developed Codes of Practice have been adopted in the sector, but an independent audit system has not been implemented ▪ The Ontario aquaculture sector is having difficulty to attract investment to finance industry expansion and diversification ▪ Few individuals can afford to enter the sector today – access to capital for aquaculture development can be difficult

Horizontal Causal Analysis

Identified Problems	How is the issue manifest?	Why is it happening? Underlying causes?	Why is it important? (Opportunities & Repercussions)
Marketing Factors			
Chile, Argentina and Peru are leading exporters of trout to the US and Canada (principally frozen but some fresh)	▪ S. America exports more volume of trout into US markets than Canada ▪ US marketers establish supply contracts with S. American producers	▪ Lower cost of production in S. America – fish size tends to be larger than what the Cdn sector is producing today. ▪ The frozen product does not compromise shelf-life and reduces transportation costs	▪ Loss of market share in domestic and US export markets ▪ Capacity to displace imports in Cdn and US markets ▪ Most of Canada's freshwater trout production is consumed in Canada
Increasing buyer power / Decreasing supplier power	▪ Buyers contracting directly with producers that can meet their volume and product type requirements	▪ Consolidation of buyers (retail & foodservice) leading to high volume accounts ▪ Role of retail chains in the sector; i.e. Costco, Wal-Mart	▪ Loss of market share if production volumes do not increase to service buyers' requirements ▪ Capacity to displace imports in Cdn and US markets
Price point competition from beef, pork, poultry	▪ Lower price/kg for many alternative protein sources at retail and foodservice	▪ Cost of production for trout (e.g. feed costs) ▪ Trout poorly promoted as a centre-of-plate staple	▪ Lower costs will boost profits and increase demand
Insufficient Production Capacity	▪ Insufficient product to meet demand from large customers ▪ Continuity of supply is compromised at times	▪ Inability to expand output at existing sites or via the development of new sites due to regulatory constraints	▪ Loss of customers over time as supply is sourced elsewhere ▪ Loss of potential to displace imports in growing Cdn and US markets ▪ Loss of potential to increase volume and socio-economic benefits in rural ON
Technological and Production Factors			
Inability to expand production capacity	▪ No new net-pen culture site tenures in recent years aside from those in First Nations traditional territories	▪ Current policy & regulatory framework not conducive to approving changes; open-ended processes; lack of clear standards ▪ No dispute resolution or appeal process re licence conditions ▪ Cage site application process is expensive, lengthy, inconsistent and without service standards ▪ Opposition from environmental & other specific interest groups ▪ Unresolved Land Claims – Gov't is deferring decisions	▪ Loss of customers over time as supply is sourced elsewhere ▪ Inability to improve competitiveness through economies of scale. Sector runs the risk of becoming marginalized. ▪ Loss of potential to displace imports in growing Cdn and US markets ▪ Loss of potential to increase socio-economic benefits in rural ON

Fingerling supply in Ontario may become limited	▪ A limited number of hatcheries	▪ Consolidation in fingerling supply sector ▪ No new hatcheries built in more than a decade	▪ Reduced production capacity if key biological resource is limited ▪ Significant risk to the expansion
Dependence on US supply of eggs	▪ Limited domestic broodstock population ▪ A declining number of hatcheries ▪ Increased egg imports	▪ Lack of a robust genetic selection process to improve quality and traits of ON stocks ▪ Better perceived quality from US suppliers ▪ Year-round availability from US suppliers (only spring and fall eggs from ON hatcheries)	▪ Border closure for disease control could cripple the sector – significant reduction in output until alternative suppliers can become established ▪ Insufficient domestic capacity to replace imports in a timely manner ▪ Lost opportunity to enhance the capacity of ON hatchery sector ▪ Potential to enhance genetic traits for benefit of producers
Ecological challenges and pressures	▪ Cases of effluent non-compliance ▪ Escaped fish ▪ Disease and use of therapeutic agents	▪ Stringent and out-dated effluent compliance standards ▪ No waste collection at cage sites; externalization of organic waste ▪ Occasional loss of fish ▪ Occasional need for veterinary intervention ▪ Poor communication and misinformation regarding the environmental effects of aquaculture ▪ Codes of Practice not fully implemented with performance audits ▪ Best diets and feeding strategies not used by all	▪ Inability to secure a social licence to enable the industry to develop & prosper ▪ Continued opposition to industry development ▪ Continued inability to secure access to sites for net-pen culture ventures
Disease Management	▪ Economic losses due to cold water disease, columnaris and furunculosis are too high	▪ Lack of effective management regimens for these three diseases ▪ Too few approved therapeutic agents ▪ Insufficient veterinary services ▪ Codes of Practice (biosecurity & fish health measures) not fully implemented with performance audits	▪ Reduced capacity to lower overall cost of production and improve competitiveness ▪ Potentially damaging to marketability due to perceptions about the quality of fish and sustainability of operations

Socio-Political & Environmental Factors			
Public opposition to net-pen aquaculture	▪ Lobbying to curtail aquaculture in Georgian Bay	▪ Net pen culture sector is precluded from adopting practices to enhance	▪ Inability to secure a social licence to enable the industry to develop & prosper

	▪ Inability to access new net-pen sites ▪ Lack of social licence for aquaculture development	sustainability (e.g. site fallowing) ▪ Net pen culture lacks property rights ▪ User-group conflict is couched as 'environmental' ▪ Public opinion is shaped by media reports of west coast salmon farming issues ▪ Poor communication of objective information re aquaculture to stakeholders ▪ Considerable research but results are not widely disseminated ▪ Insufficient research into social aspects of the sector; social scientists are not effectively engaged to study the sector ▪ Codes of Practice not fully implemented with performance audits	▪ Continued opposition to industry development ▪ Continued inability to secure access to sites for net-pen culture ventures ▪ Loss of potential to increase socio-economic benefits in rural ON
Compromising International (IJC) Water Quality Agreements	▪ Deposition of phosphorus into Great Lakes	▪ No solid waste collection at cage operations. ▪ Other nutrient management techniques (i.e. feed quotas) are under-valued. ▪ Misunderstanding of characteristics & environmental effects of phosphorus derived from aquaculture ▪ Misunderstanding of Limnology; Lakes are not static – but dynamic entities	▪ May compromise the credibility of the Minister(s) and the Province ▪ Potential legal issues
Inadequate security of site tenure	▪ Investors lack confidence in the sector due to tenure risk ▪ No process for dispute resolution re tenures & licence conditions	▪ The industry has no Restoration Fund (Bond) to deal with the obligations of derelict operators ▪ Provincial policy and regulatory approach is inconsistent	▪ Inability to secure financing for industry growth
User Group Conflict	▪ Public opposition to a net-pen culture ▪ Gov't reluctance to allocate new net-pen culture sites ▪ Industry precluded from applying more sustainable practices (i.e. site rotation, upgraded treatment works in	▪ Shared federal/provincial policy and regulatory framework is cumbersome to implement and enforce ▪ Contrary to objectives and decision-making amongst Ministries ▪ Not enough objective information about net-pen aquaculture being	▪ Inability to secure a social licence to enable the industry to develop & prosper ▪ Continued opposition to industry development ▪ Continued inability to secure access to sites for net-pen culture ventures ▪ Loss of potential to increase socio-economic benefits in rural ON

	land-based operations)	communicated effectively to stakeholders ▪ Mandated monitoring & reporting done largely for compliance, not used for adaptive management ▪ Unwillingness to grant additional sites for rotation/fallowing ▪ Excessive costs to amend ECA for improved treatment works ▪ Lack of a clear ON policy position on commercial rainbow trout farming ▪ No service standards for approvals ▪ Insufficient research into alternative modes of production (e.g. large-scale pump-ashore facilities)	

Identified Problems	How is the issue manifest?	Why is it happening? Underlying causes?	Why is it important? (Opportunities & Repercussions)
Economic Factors			
Difficult to enhance competitiveness & lower cost of production	▪ Inability to expand via organic growth or at new sites in ON ▪ Ontario moving to 'fair market value' for resource-use ▪ Loss of market share to the east coast and S. American producers	▪ No growth potential ▪ Producers not able to access safety net programs available to agriculture ▪ Lack of a clear ON policy position on commercial aquaculture ▪ Lack of a robust genetic selection process to improve quality and traits of ON stocks ▪ Cannot take advantage of economies of scale	▪ Loss of potential to increase socio-economic benefits in rural ON ▪ Reduced competitiveness vis-a-vis S. American producers ▪ Erosion of market share
Lack of investor confidence in the sector	▪ Inability to access capital ▪ High borrowing costs ▪ Few players can enter the sector (entry barrier)	▪ Producers not able to access safety net programs available to agriculture ▪ Codes of Practice not fully implemented with performance audits ▪ No industry bench-marking system to support performance improvement	▪ The Sector will not achieve its potential to enhance its footprint as a sustainable generator of wealth for the citizens of the Province.

Vertical Causal Analysis

Key causal factors from Horizontal analysis

- The cost of producing trout is lower (fob plant) in S. America for frozen 2-3 kilo products.
- Consolidation of buyers (retail & foodservice) means key accounts are demanding larger and more consistent volumes from suppliers
- The cost of production for trout is variable (depending on the region and the scale of the operation.
- Lack of consolidated effort and resources from producers for dealing with common issues
- Inability to expand output due to current site management restrictions
- Current aquaculture related policies & regulatory framework not conducive to the development
- Net pen site application process is expensive, lengthy, inconsistent
- Opposition from environmental & other specific interest groups
- Unresolved Land Claims are used as justification to stall development of net-pen aquaculture site applications
- Lack of a robust genetic selection program to improve the quality and traits of ON stocks. They are not being selected for performance in net-pen culture.
- Perception of a lack of regulatory oversight for net pen production. Other nutrient management techniques (i.e. feed quotas) are under-valued.
- Insufficient research into alternative modes of production (e.g. large-scale pump-ashore facilities)
- Occasional loss of fish from farms
- Poor communication from the Industry and misinformation about industry practices
- Codes of Practice not fully implemented with performance audits
- Best diets and feeding strategies not used by all farmers
- Too few approved therapeutic agents
- Net pen culture sector is precluded from adopting practices to enhance environmental sustainability (e.g. site fallowing)
- Net pen culture operations lack property rights. This is contrary to other farming activities in ON. Lack of a clear ON policy position on commercial aquaculture
- Public opinion is often shaped by media reports of west coast salmon farming issues
- “Sustainable Development“ is based on three pillars: Economic Prosperity, Environmental Protection and Social Well-Being. There is Insufficient research into social aspects (good/bad) of the sector
- Insufficient input from local communities that are impacted (positively/negatively) by the Sector
- Misunderstanding of characteristics & environmental effects of phosphorus derived from aquaculture
- The industry has no Restoration Fund (Bond)
- Shared federal/provincial policy and regulatory framework is cumbersome
- Contrary objectives and decision-making amongst provincial ministries
- Producers not able to access safety net programs
- Difficult to take advantage of economies of scale
- No industry benchmarking system to support performance improvement
- Global economic forces beyond the influence of sector

What Needs to Be Addressed

Description of Underlying Cause	Problem(s) Addressed	Frequency	Priority and Importance		
			Low	Med	High
1. There is limited ability to grow the sector due to restrictions to accessing new net-pen culture sites in the Great Lakes. This affects the ability to generate economies of scale and address market demands.	M1, M2, M3, M5, P1, E1, E3, E4	8			X
2. Over-dependence on two major US suppliers of genetic material (eyed eggs) is an unacceptable risk. There is no formal genetic selection program for rainbow trout farmed under net-pen culture conditions.	P2, P3, E1, M3	4		X	
3. There is a crisis in confidence regarding aquaculture in Ontario (particularly net-pen aquaculture) despite the availability of technologies and practices to mitigate concerns.	P1, P4, P5, SPE1, SPE2, SPE4, M4	7			X
4. Provincial policy, regulations and processes are not conducive to rainbow trout net-pen aquaculture; complicated by federal/provincial overlap.	P1, SPE3, SPE4, E1, E2	5			X
5. Best Management Practices (BMPs) with Standard Operating Procedures (SOPs) that are independently audited by 3rd parties to provide transparency and credibility are not implemented across the Sector. Crop/production insurance and other safety-net programming are not available to aquaculture.	P4, E1, SPE1	3	X		

Appendix D – Consulting Team

W.D. (Bill) Robertson – SENIOR CONSULTANT

Based in St Andrews, New Brunswick, Bill has been involved in the development of the fisheries and aquaculture sector in Canada for over twenty-five years. He is the President of ReThink Inc (www.rethinkinc.ca) and combines his management experience with a background in business and science. Bill is a Certified Management Consultant (www.cmc-canada.ca), a certified Project Management Professional (www.pmi.org) and has a Six Sigma Black belt and SCRUM designations for productivity improvement. He joined the private sector in 1998 to become the Manager, Fish Culture Operations for Connors Bros., Limited and was promoted to the position of Director, East Coast Operations for Heritage Salmon Limited. Both Connors and Heritage were wholly-owned subsidiaries of George Weston Ltd; a publicly-traded multinational food conglomerate based in Toronto, Ontario (www.weston.ca). With full P&L responsibilities, he oversaw fresh and frozen seafood production facilities and had labour force accountabilities of over 400 staff in Canada and the northeastern US.

Bill is the former Executive Director of the Huntsman Marine Science Centre (www.huntsmnmarine.ca) – a not-for-profit marine research and teaching institution; where he led the organization through a governance and financial restructuring process as well as a major capital campaign to rebuild the asset base including the research laboratories, the residences, and the public aquarium.

He served as the first President of the Board of Directors for Enterprise Charlotte, part of the Province of New Brunswick`s regional economic development strategy for addressing the needs of rural and coastal communities. He also served as a Director of the New Brunswick Fisheries Loan Board, a financial services instrument for the commercial fisheries sector.

Daniel Stechey – SENIOR CONSULTANT

Based in Cobourg, Ontario, Daniel Stechey established Canadian Aquaculture Systems Inc. (www.canadianaquaculturesystems.com) in 1984 as a full-service consulting agency providing technical, strategic and operational solutions pertaining to the design, development, productivity and competitiveness of commercial aquaculture operations. Daniel is a Certified Management Consultant. He possesses an extensive and multi-disciplinary skill set which, combined with his analytical and management expertise, are effective tools to enhance the competitiveness of CAS' clientele.

From 1992-96, at the request of both Industry and the Government of Canada, Daniel served as the first Director of Aquaculture Policy for Fisheries and Oceans Canada (DFO), where he was responsible for the development and delivery of policies, programs and services to facilitate the sustainable expansion of commercial aquaculture in Canada. Daniel was the principal architect of the Federal Aquaculture Development Strategy. From 2000 through 2004 he also served as a Special Advisor to Canada's Commissioner for Aquaculture Development.

He is the author/co-author of more than two dozen publications, two book chapters and more than 200 technical, economic, policy and design reports. The latter encompasses all aspects of aquaculture design, development and management including:

- Environmentally sustainable aquaculture
- Technical & operational performance assessments
- Facility design and management
- Market & economic reviews
- Strategic planning and development
- Aboriginal economic development
- Best Management Practices
- Risk assessment/management and crop insurance programming
- Canadian Shellfish Sanitation Program renewal
- Processing plant operational reviews
- Reviews to assess insured losses
- Feasibility assessments and business planning

Jan Linquist- – SENIOR ADVISOR, Environmental & Water Resources Management

Ms. Linquist has over 40 years of experience in environmental/water resources management with the Ministry of Environment (20 years) and as a consultant (23 years). In these roles, she has conducted numerous studies and assignments related to the environmental impacts of aquaculture operations in freshwater systems. With the Ontario Ministry of Environment, she was responsible for environmental permitting reviews and monitoring programs for net-pen aquaculture operations in Northeastern Region and represented Region on MOE's Provincial Aquaculture Committee.

With N.A.R. Environmental Consultants Inc., Jan completed approximately nine environmental baseline assessments for net-pen culture operations in Ontario and conducts annual water quality monitoring programs, sediment and benthic macroinvertebrate surveys on behalf of the cage operators for submission to Provincial agencies. She was a member of the science review panel for DFO's *Estimation and Assessment of the Risk of Phosphorus Inputs from the Net pen aquaculture Industry to Canadian Freshwater Environments*, completed a *Review of Water Quality Monitoring Data for Net pen aquaculture Facilities in Ontario, 1982 – 1999* for DFO (OCAD) and EC (Ontario Sustainable Aquaculture Working Group), was a member of MOE's Team 1 Committee which developed the *Recommendations for Operational Water Quality Monitoring at Net pen culture Aquaculture Operations* and participated in the development of the *Best Management Practices for Sustainable Aquaculture in Ontario* for the Northern Ontario Aquaculture Association. On a global scale, she provided revisions to the water quality chapters to the Freshwater Trout Aquaculture Dialogue for the World Wildlife Fund in 2010 and completed a *Review of Regulatory Compliance in Canadian Aquaculture with the UN FAO Code of Conduct for Responsible Fisheries and the Technical Guidelines on Aquaculture Certification* for Global Trust Alliance in 2012. In recent years, she has completed approximately five similar feasibility reviews for the establishment of net-pen aquaculture sites.

Terry Drost - SENIOR ADVISOR, Seafood Sales & Marketing

Terry has worked in the Canadian aquaculture industry since 1987. During the last 33 years, Terry has travelled to many of the major aquaculture producing areas of the world, including Norway, Scotland, Chile and Australia for his work in fish feed production. He has continued his personal development by attending many international conferences and seminars on fish husbandry, nutrition and health, as well as sales and marketing. Terry also has expertise in quality control processes and in exporting products to other countries.

Terry graduated from the University of Guelph with a Bachelor of Science in Agriculture in February 1987. Terry joined Corey Feed Mills Ltd. of Fredericton, New Brunswick, in March 1987 as Production Manager for all Aquaculture related fish feeds. In 1988, Terry took on the responsibilities of sales and marketing for aquaculture feeds. The company produced fish diets for a variety of species of fish, including Atlantic salmon, Rainbow trout, Arctic Char, Halibut, Tilapia and Cobia, among others.

In 2008, Terry joined a group of Atlantic salmon producers to form a salmon sales and marketing company, *ESQU* Seafood Ltd. Terry helped to establish a brand of premium farmed seafood in the northeast of North American markets. In 2011, Terry formed his seafood sales and marketing consulting company, Four Links Marketing Ltd., which he continues to operate.

Terry has participated and received the following training and education over his career:

- November 2019: Introduction to Good Manufacturing Practices, Pharmaceutical Sciences Group, Charlottetown, PEI
- January 2015: Best Aquaculture Practices Auditor Training Course, Global Aquaculture Alliance, Ann Arbor, Michigan
- October 2010: GlobalGAP Certification Conference, London, England
- February 2007: Certified HACCP Manager, Thomson Prometric
- February 2006: Effective Personal Productivity, Leadership Management International, Waco, Texas
- December 2006: SQF Systems: Course on Implementing SQF Systems, SQF Institute
- February 2005: Queen's Leadership Program; 1 week intensive Course, Queen's School of Business
- May 2004: Professional Sales Management Course, Canadian Professional Sales Management Association
- January 2003: Managing Your Operations: A Team Approach to Improving Your Performance, Saint Mary's University
- April 2002: Effective Negotiating and Influencing Skills, Saint Mary's University
- December 1999: Key Account Management, Saint Mary's University

During the last nine years of operating Four Links Marketing Ltd., Terry has been involved with several large projects including The Development of Offshore Aquaculture project for ACOA, an Aquaculture Branding Project for the Aboriginal Aquaculture Association commissioned by the Department of Fisheries and Oceans, as well as several proprietary business development projects for small and medium-sized companies.

William (Bill) Hogans - SENIOR ADVISOR, Freshwater Aquaculture Development

Bill has been engaged in the development of freshwater and marine aquaculture for more than 25 years. In 1994, he founded Tongue Shoal Aquasciences, a biological consulting company providing design and operational management services in the areas of aquaculture, fish parasitology, fisheries and environmental biology. Through Tongue Shoal, he served as the Principal Consulting Biologist to Breviro Caviar, a New Brunswick-based producer of farmed sturgeon and caviar.

Bill has extensive experience in the culture techniques for several species including Atlantic salmon, arctic char, hybrid and pure striped bass, Atlantic sturgeon, Shortnose Sturgeon, tilapia, Atlantic halibut, Atlantic cod and American eel. He has also developed techniques for the production of live food and for rearing the early life stages of several freshwater and marine finfish species. He was the first to develop techniques for spawning and rearing shortnose sturgeon (Acipinser brevirostrum) in Canada.

As a recognized North American authority on the parasites and diseases of cultured fishes, Bill has published more than 60 primary papers and book chapters on various aspects of fish parasitology, aquaculture and fisheries biology. He has designed and assisted in the construction of several commercial-scale finfish intensive recirculation and shellfish depuration systems. He has BA, BS and MS degrees from the University of Delaware

In 2019, Bill completed a 5-year engagement with the New Brunswick Department of Agriculture, Fisheries and Aquaculture as a Senior Business Growth Development Officer