

Aquaculture Technologies

RESOURCE DOCUMENT

MARCH 31, 2018



**NATIONAL INDIGENOUS
FISHERIES INSTITUTE**

Indigenous Program Review

**INSTITUT NATIONAL DES
PÊCHES AUTOCHTONES**

Examen des programmes autochtones

indigenousfisheries.ca

Table of Contents

Executive Summary	3
<hr/>	
Introduction	4
<hr/>	
Section 1	
Aquaculture Contacts and References	5
<hr/>	
A: Canadian Not-For-Profit Organizations	5
B: USA Not-For-Profit Organizations	6
C: Canadian Businesses in the Aquaculture Sector	7
D: USA Businesses in the Aquaculture Sector	9
E: International Businesses in the Aquaculture Sector	11
<hr/>	
Section 2	
Canadian Context for Technology and Innovation in the Aquaculture Sector	12
<hr/>	
Section 3	
Natural Marine Environment Systems	15
<hr/>	
Section 4	
General Aquaculture Issues	22
<hr/>	
Section 5	
Aquaculture Economics	24
<hr/>	
Recommendations	26

Executive Summary

Across Canada, First Nations are searching for opportunities to create sustainable commercial fisheries enterprises. First Nations have an excellent opportunity to build on their traditional experiences and practices of fishing for food and ceremonial gatherings in order to develop a commercial resource. However, for economic, social, cultural, and environmental reasons many First Nations will not consider aquaculture as a practical alternative.

What are the alternatives, opportunities, and risks for First Nations? The challenges and the solutions are as unique as the regions that wish to become involved in commercial fisheries. Many data gaps exist with respect to the technology, science, and application of aquaculture systems and processes in addressing First Nations concerns.

Through the National Indigenous Fisheries Institute (NIFI), this study was commissioned to identify and prioritize the most urgent issues of innovation and technology facing the aquaculture industry with a goal of developing a library of the world's foremost advantages for aquaculture in Canada.

The results of this study indicate a wide range of opportunity for using new technology and systems to address environmental concerns in an aquaculture environment. There are many people and companies passionate about operating in an environmentally responsible manner. The question is, "What systems and processes are appropriate to address environmental concerns in the various biogeoclimatic regions of Canada?"

Introduction

Aquaculture is a growing industry world-wide. In Canada, many First Nations are involved, while others encounter obstacles, or question the environmental impact of the industry. Many data gaps exist relating to the technology, science, and application of aquaculture systems and processes in addressing First Nation concerns.

The purpose of this work is to identify and prioritize the most urgent issues of innovation and technology facing the aquaculture industry, as well as to provide preliminary work plans for each issue. The focus of this report is to take steps towards developing a library of the world's foremost technologies and innovations for aquaculture in Canada.

This study includes technology priorities and initiatives identified by the Canadian Council of Fisheries and Aquaculture Ministers (CCFAM) Strategic Management Committee on Aquaculture and the National Aquaculture Strategic Action Plan Initiative (NASAPI). Additionally, the authors reviewed industry journals and scholarly articles while investigating the world's leading aquaculture operators and research institutes for innovation and technological issues applicable to a Canadian context; specifically, for the northern environment.

This report identifies the new and emerging technologies and processes that are available to be applied to the situation in Canada at the time of writing. This is meant as a guide, not an exhaustive listing. Users are encouraged to verify the technologies listed and seek other options that may be applicable to their geographic locations. The next step is to conduct an intensive investigation to determine which are appropriate and economically viable in a First Nations context throughout Canada.

NEXT STEP CHALLENGES

In undertaking the next steps of conducting an intensive investigation, it must be kept in mind that the aquaculture industry is rapidly maturing from proof of concept and feasibility, to becoming profitable.

This is drawing investors who are working to create competitive advantages, which is illustrated by a demonstration of greater secrecy of proprietary systems. Thus, gaining access to information on technology will require a higher level of trust and greater face-to-face interaction to conduct required research.

Continued investigation will require an understanding and allocation of appropriate resources to create an environment where proprietary information will be shared.

Section 1

Aquaculture Contacts and References

Below is a summary of some of the more important aquaculture contacts and references located throughout the world.

A: Canadian Not-For-Profit Organizations	
These not-for-profit organizations represent various interests in the Canadian aquaculture sector.	
<p>CANADIAN AQUACULTURE INDUSTRY ALLIANCE (CAIA)</p> <p>The Canadian Aquaculture Industry Alliance (CAIA), located in Ottawa, Ontario is a national association of Canada’s seafood farmers representing their interests in Ottawa to regulators, policy makers and political leaders. Membership reaches coast to coast to coast, comprised of finfish, shellfish and aquatic plant farmers, feed companies and suppliers, as well as regional aquaculture associations. CAIA is a passionate advocate for the quality and sustainability of farmed seafood.</p>	<p>Suite 1650, 220 Laurier Avenue West Ottawa, ON, K1P 5Z9</p> <p>t 613-239-0612</p>
<p>CANADIAN SCIENCE ADVISORY SECRETARIAT (CSAS)</p> <p>The CSAS promotes and provides a range of science advisory activities related to closed containment and saltwater salmon aquaculture.</p>	<p>Michael Chadwick Fisheries and Oceans Canada Gulf Fisheries Centre P.O. Box 5030 Moncton New-Brunswick E1C 9B6</p> <p>e Michael.Chadwick@dfo-mpo.gc.ca t 506- 851-6206</p>
<p>COASTAL ALLIANCE FOR AQUACULTURE REFORM (CAAR)</p> <p>CARR, located in Vancouver BC, is a coalition of four leading environmental organizations working to transition the open-net cage salmon farming industry to more sustainable production methods. One of the major participants is the David Suzuki Foundation. They promote themselves as a reliable source of information on the problems of and solutions to open-net cage salmon farming. The coalition focuses on five key areas – markets, campaigns, local outreach, science, negotiations with industry and policy reform.</p>	<p>207 West Hastings, Suite 1405 Vancouver, BC V6B 1H7</p> <p>e info@farmedanddangerous.org t 604-696-5044</p>
<p>THE CANADIAN COUNCIL OF FISHERIES AND AQUACULTURE MINISTERS (CCFAM)</p> <p>The Canadian Council of Fisheries and Aquaculture Ministers (CCFAM) supports continued growth in aquaculture production that is environmentally, socially and economically sustainable. The CCFAM comprises federal, provincial and Yukon government ministers who have set out to accomplish a collaborative three-year plan designed to achieve the following outcomes:</p> <ul style="list-style-type: none"> • Improved federal/provincial/territorial regulatory framework; • Improved coordination of aquaculture fish health management; and • Improved support for regional economic growth through aquaculture. 	<p>Fisheries and Oceans Canada 200 Kent St., Station 13E228 Ottawa ON, K1A OE6</p> <p>e info@dfo-mpo.gc.ca t 613-993-0999</p>

B: USA Not-For-Profit Organizations

These not-for-profit organizations represent various interests in the United States aquaculture sector.

DEPARTMENT OF ANIMAL SCIENCES, UNIVERSITY OF WISCONSIN-MADISON

The Department of Animal Sciences, Aquaculture Research Laboratory studies basic hormonal mechanisms in fish. They work to enhance aquaculture production and understand the impact of endocrine disruptors on wild fish populations. Through applied aquaculture research, they have developed improved fish-rearing strategies and novel feed additives that promote fish growth and survival.

Department of Animal Sciences,
University of Wisconsin-Madison
Dr. Terence P. Barry
660 N Park St.
Madison, WI 53706

e tpbarry@wisc.edu
t 608-262-6450
c 608-843-1425

DEPARTMENT OF THE INTERIOR, US GEOLOGICAL SURVEY

The USGS has developed technology for tracking toxic algae blooms using satellites.

Department of the Interior, U.S.
Geological Survey
Keith A. Loftin, Ph.D.
USGS Kansas Water Science Center
12201 Sunrise Valley Drive
Reston, VA 20192

e kloftin@usgs.gov
t 785-832-3543

NOFIMA

Nofima is one of the largest institutes for applied research within the fields of fisheries, aquaculture and food research in Europe. It is located in Tromsø, Norway, a major cultural hub above the Arctic Circle. The organization's goal is to conduct research that leads to development of solutions resulting in competitive advantages along the complete value chain.

Nofima
Morgan Lillegard
Chief Information Officer
Phone: +47 416 10 130

e morgan.lillegard@nofima.no
t (47) (77) 62-900

PACIFIC COAST SHELLFISH GROWERS ASSOCIATION

The Pacific Coast Shellfish Growers Association (PCSGA) represents growers in Alaska, Washington, Oregon, California, and Hawaii. Their members grow a wide variety of shellfish including oysters, clams, mussels and geoduck. PCSGA works on behalf of its members on a broad spectrum of issues, including environmental protection, shellfish safety, regulations, technology and marketing.

Pacific Coast Shellfish Growers
Association
1202 State Ave NE
Olympia, WA 98506

t 360 - 754 2744

C: Canadian Businesses in the Aquaculture Sector

These businesses operate in Canada providing services, supplies and materials to the aquaculture sector across Canada.

AGRIMARINE HOLDINGS

AgriMarine Holdings is a Canadian-based aquaculture company specializing in fish farming and developing sustainable technologies for commercial aquaculture applications. The company operates its farming division through West Coast Fish Culture Ltd, growing Steelhead salmon, and its technology division through AgriMarine Technologies Inc.

AgriMarine Holdings
Travis Schneider
Manager, Corporate Affairs
900 W Hastings St #710,
Vancouver, BC V6C 1E1

e travis@agrimarine.com

AKVA GROUP

The AKVA Group is present in markets worldwide with offices in Canada, Norway, Chile, Denmark, Scotland, Spain, Iceland, Australia and Turkey. The company has the capability to offer both cage farming and land based aquaculture operations with complete technical solutions and services. Some examples are:

- AC 400 feed barges now feeding 2.3 million salmon each day near Shenzhen, China.
- Systems for producing Highland Trout in Chile.
- Wavemaster cages on Vancouver Island.
- Installation of an eight-unit brood stock site for Greater Amberjack will secure fertilized eggs throughout the year for the annual production of 5000 tons.
- An installation of AKVA Group recirculation tanks for farming Bluefin Tuna was awarded the world's 2nd best invention in 2009 by Time Magazine.

AKVA Group
Keith Richford
Sales & Marketing Manager
1495 Baikie Rd, Campbell River BC
V9W 0C2

e krichford@akvagroup.com
t 250-286-8802

AQUA-PAK INDUSTRIES, LTD.

Aqua-Pak Industries provides Styro Boxes® (expanded polystyrene packaging) for the aquaculture industry.

Aqua-Pak Industries Ltd.
7398 - 132nd St
Surrey, BC V3W 4M7

e aquapak.com/contact_us
t (604) 590-2886

BUHLER (CANADA) INC.

Buhler provides feed systems to the aquaculture industry, operating throughout the world.

Bühler (Canada) Inc.
7270 Woodbine Av. Suite 202
Markham, Ontario L3R 4B9
Phone: (905) 940 69 10

e buhlergroup.com/global/en/about-buehler/contact

COREY AQUAFEEDS

Corey Aquafeeds supplies nutrition for the aquaculture industry in Atlantic Canada.

Corey Aquafeeds
136 Hodgson Road
Fredericton, NB E3C 2G4
e info@Corey.ca
t 1-800-561-0072

<p>DARK SEA ENTERPRISES INC. Dark Sea Enterprises Inc. manufactures oyster tray growing systems</p>	<p>Dark Sea Enterprises Inc. 47 Glenmore Drive West Vancouver BC, V7S 1A5</p> <p>t (604) 926-1050</p>
<p>MEEKER'S AQUACULTURE Recognizing that fish-processing waste and sawdust waste from local mills offered potential as fertilizer, the Meekers began an onsite composting operation which today produces approximately 40 tonnes of 'Meeker's Magic Mix' weekly. In 2010 the company won the "Premier's Award for Agri-Food Innovation Excellence.</p>	<p>Meeker's Aquaculture Mike and Sharon Meeker 228 Noland Blvd., RR#1, Evansville, ON</p> <p>t 705-282-3101</p>
<p>OSI OXYGEN SOLUTIONS INC. OSI is a Canadian technology company. Since 2003, the company has been engaged in development, commercial manufacturing and world-wide distribution of oxygen generators for increasing oxygen flow in aquaculture applications.</p>	<p>OSI Oxygen Solutions Inc. 17338-106A Avenue, Edmonton, Alberta</p> <p>t (780) 444-7666 e info@osioxygen.com</p>
<p>PHIBRO ANIMAL HEALTH CORPORATION Phibro is a producer of nutritional and mineral specialties for the aquaculture industry. They deliver customized, solutions addressing production and operations, fish health management, disease diagnosis and vaccination. Phibro has the capability to perform clinical studies and assessments, and are equipped to conduct studies in fresh, salt and brackish water, with the added ability to cool or heat water year-round. Their laboratory enables full diagnostic parasitology, bacteriology, histopathology and molecular-biology analysis.</p>	<p>Phibro Animal Health Corporation 1500-1874 Scarth Street Regina, Saskatchewan, S4P 4E9</p> <p>t (306) 347-8475</p>
<p>SKRETTING (CANADA) Skretting manufactures and supplies aquaculture feeds, making it an essential link in the feed-to-food chain world-wide. They work to develop innovations that achieve optimum nutritional value, sustainable production and economic performance in an aquaculture context.</p>	<p>Skretting (Canada) 1370 East Kent Avenue, Vancouver, BC, Canada</p> <p>t (604) 325 0302 e west.sales@skretting.com</p>
<p>SYNDEL CANADA Syndel Canada has develops and markets high quality aquaculture chemicals and pharmaceutical products worldwide. They specialize in aquatic animal health solutions for fish reproduction, disease prevention, treatment and biosecurity.</p>	<p>Syndel Canada 2595 McCullough Rd Nanaimo, BC V9S 4M9 Canada</p> <p>e info@syndel.ca t (800) 663-2282 t (250) 585-2006</p>
<p>TIDAL ENTERPRISES LTD. Tidal Enterprises is a supplier of rope, alloy chain, compensator buoys, netting and rigging hardware to the Aquaculture sector.</p>	<p>Tidal Enterprises Ltd. 120 Fry Street Nanaimo, British Columbia, V9R 4Y9</p> <p>e areid@tidalropes.com t (250)-756-7595</p>

D: USA Businesses in the Aquaculture Sector

These businesses operate in the United States providing services, supplies and materials to the aquaculture sector.

AQUATIC EQUIPMENT AND DESIGN INC.

Aquatic Equipment and Design Inc. is a United States supplier of products for recirculating aquaculture systems and ponds required for an aquaculture environment. They offer a full line of aquatic products, as well as design and engineering services.

Aquatic Equipment and Design Inc.
30924 Suneagle Dr. #210
Mount Dora, Florida, USA, 32757

e info@aquaticed.com
t (407) 995-6490

AQUA HILL AERATION, INC.

Aqua Hill Aeration provides equipment to lift waste, and oxygenate, de-gas, pump, and filter water in high volumes. Their equipment can be utilized to maintain a stable culture environment in both fresh and saltwater recirculating aquaculture systems (RAS), ponds, and various other aquaculture, aquaponics, and hydroponic applications.

Aqua Hill Aeration Inc.
960 Elston Rd.
Lafayette, IN, USA, 47909

e Info@AquaHillAeration.com
t (765) 337-7013

AQUACULTURE SYSTEMS TECHNOLOGIES, LLC.

Aquaculture Systems engineers and manufactures water filtration solutions for high-volume applications.

Aquaculture Systems Technologies, LLC.
108 Industrial Avenue
New Orleans, LA 70121

t 1-866-899-9056

AQUAFLO

Aquaflor (florfenicol) is approved for controlling mortality in freshwater-reared salmonids due to *Flavobacterium psychrophilum* (coldwater disease), furunculosis associated with *Aeromonas salmonicida* and columnaris disease associated with *Flavobacterium columnare*.
Key Contact Information

Intervet Canada Corp
Aquaflor (Canada)
16750 Route Transcanadienne
Kirkland, Quebec, H9H 4M7, Canada
aquaflor-usa.com

t 1-866-683-7838
t 514-428-7013

AQUATIC ENTERPRISES, INC.

Aquatic Enterprises, with their in-house engineering and manufacturing capabilities, design and build virtually any aquatic holding system or hatchery equipment required for the aquaculture sector.

Aquatic Enterprises, Inc.
West Coast Office
4101 W Marginal Way SW, Suite A-6
Seattle, WA 98106

e info@aquaticenterprises.com
t (206) 937-0392

AQUATIC SOLUTIONS

Aquatic Solutions supports the aquaculture industry by providing a one-stop-shop for most supplies, equipment and materials required.

Aquatic Solutions
PO Box 30067 Des Moines
Iowa USA 50310

e rich@MyAquaticSolutions.com
t (515) 276-2782

<p>BIG FIN SCIENTIFIC</p> <p>Big Fin Scientific software and systems are used by fishery managers, fish scientists and field and animal researchers of all types to assess the health of animal and fish populations.</p>	<p>Big Fin Scientific 7200 TX-71, Austin TX, USA, 78735</p> <p>e info@bigfinscientific.com t 512) 808 0346</p>
<p>CHRISTENSEN NET WORKS</p> <p>Christensen Net Works offers high quality netting products and solutions for a wide variety of custom applications in the aquaculture sector. Some of their products include:</p> <ul style="list-style-type: none"> • Dip Nets to meet any specification and for any fish application from fry to adult; • Custom built seines for any application; • Net pens for hatcheries, fish farms, and ocean farming operations. 	<p>Christensen Net Works 401 Lincoln Street Everson Washington USA, 98247</p> <p>e info@cnwnetting.com t 1-800-459-2147</p>
<p>FRESH-FLO CORPORATION</p> <p>Fresh-flo is an American manufacturer of a variety of products for the aquaculture sector used to restore adequate oxygen, reduce water temperatures, dislodge obnoxious gases, dissolve organic wastes, and prevent freeze-out in large and small bodies of water.</p>	<p>Fresh-flo Corporation 3037 Weeden Creek Road Sheboygan WI, USA. 53081</p> <p>e barb@freshflo.com t (920) 208-6533</p>
<p>GO DEEP SHELLFISH AQUACULTURE</p> <p>Go Deep Shellfish Aquaculture specializes in product development, shellfish farming techniques, manufacturing and distribution of shellfish aquaculture grow-out equipment.</p>	<p>Go Deep Shellfish Aquaculture</p> <p>e godeepaquaculture.com/contact t International: 1-506-633-7850 t North America): 1-877-446-3337</p>
<p>IN-SITU INC.</p> <p>In-Situ Inc. provides water quality monitoring solutions for the aquaculture industry. Their equipment allows for real-time data collection and automated alerts that help prevent fish kills and enables instant response to changes.</p>	<p>In-Situ Inc. Camas, Washington, USA</p> <p>e sales@in-situ.com t (970) 498-1500</p>
<p>LYNDON FISH HATCHERIES INC.</p> <p>Lyndon Fish Hatcheries is a privately-owned company. They specialize in the breeding and selling of Rainbow Trout fingerlings and eggs to fish farms in Ontario and abroad.</p>	<p>Lyndon Fish Hatcheries Inc. 1738 Queen St, New Dundee, ON, N0B 2E0</p> <p>e sales@lyndonfishhatcheries.com t 519-696-3076</p>
<p>PLASTATECH ENGINEERING, LTD.</p> <p>Plastatech manufactures water-impermeable geomembranes is designed for aquatic environments, including closed ponds for aquaculture purposes.</p>	<p>Plastatech Engineering, Ltd 725 Morley Dr. Saginaw MI, USA, 48601</p> <p>e info@plastatech.com t (989) 754-6500</p>

<p>POLYTANK INC.</p> <p>Polytank manufactures and distributes plastic tanks, drain kits, trays and totes for the aquaculture sector.</p>	<p>Polytank Inc. 62824 250th Street Litchfield MN, USA, 55355</p> <p>e Dan@PolyDome.com t (320) 693-8370</p>
<p>RK2 SYSTEMS, INC.</p> <p>RK2 Systems manufactures water filtration technology equipment suited for both large and small saltwater and freshwater aquaculture applications. They also offer modular systems, allowing them to handle any application size. Examples of their equipment includes, ozone generators, automated system controls, high-flow / low amperage pumps, fluidized sand filters, bio-media, PVC and tank fittings, filtration system reservoirs, bag filtration, UV sterilizers, heaters, chillers and heat exchangers.</p>	<p>RK2 Systems, Inc. 225 S. Bent Ave. San Marcos, CA. 92078</p> <p>e rk2.com/contact1.php t (760) 746-7400</p>
<p>VMG INDUSTRIES INC.</p> <p>VGM Industries manufactures and sells the Van Gaalen Fish Egg Sorter to the aquaculture sector.</p>	<p>VMG Industries Inc. 2972 Bellmeade Way, Longmont CO, USA, 80503</p> <p>e vmgindustries.com/contact-us t (303) 682-8890</p>
<p>WATER MANAGEMENT TECHNOLOGIES INC.</p> <p>Water Management Technologies offers equipment, design, installation, start-up, and support for recirculation, intake, effluent and complete RAS systems to address water quality concerns in an aquaculture environment.</p>	<p>Water Management Technologies Inc. 17445 Opportunity Ave. Baton Rouge, LA USA, 70817</p> <p>e wmt.information@w-m-t.com t (225) 755-0026</p>
<p>YSI INCORPORATED</p> <p>YSI products enable its customers to sustainably transport, treat, test and efficiently use water in many applications, including the aquaculture sector. YSI focuses on the delivery of field, portable, online and laboratory analytical instrumentation for applications in aquaculture, as well as in other situations.</p>	<p>YSI Incorporated 1700/1725 Brannum Lane Yellow Springs Ohio, USA, 45387-1107</p> <p>e info@ysi.com t (937) 767-7241</p>

E: International Businesses in the Aquaculture Sector

These businesses operate internationally providing services, supplies and materials to the aquaculture sector.

<p>MARINE HARVEST R&D LABS, NORWAY</p> <p>Marine Harvest ASA is one of the largest seafood companies in the world, and the world's largest producer of Atlantic salmon. Their R&D focuses on developing new technologies and processes to improve salmon farming.</p>	<p>Marine Harvest R&D Labs PO Box 4102 Sandviken 5835 Bergen, Norway Sandviksboder 77AB</p> <p>t +47 21 56 23 00</p>
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Section 2

Canadian Context for Technology and Innovation in the Aquaculture Sector

In Canada, as well as in other parts of the world, significant steps are being taken to develop new technologies for the aquaculture sector. Following is a range of technologies that may provide potential opportunities to address First Nation concerns for sustainability and environmental responsibility, while bringing economic opportunity to First Nation communities. However, further study is required to confirm the appropriate application of the technologies, including economic viability.

The information below is separated by Canadian region, as follows:

All of Canada • East Coast • Central Canada • West Coast • Northern Regions

Issue for Analysis

Performance of dual drain solids' collection and removal systems for large-diameter, closed containment aquaculture systems. This issue has been identified by Canadian Science Advisory Secretariat Panel as an area where innovative solutions may lead to increased productivity, sustainability and efficiency.

Applicable Region

It is anticipated that dual drain solids' collection and removal systems will potentially be applicable to all regions in Canada. There are certainly issues of solid waste handling in extreme temperature environments that need to be studied.

Applicable Fisheries

This technology may be applicable wherever closed containment systems are utilized.

What Needs to be Studied?

There are a number of recent developments in the handling of solid waste removal; however, much of the technology is proprietary. Investigation into the applicability by climatic region and understanding the potential benefits will require engagement with system suppliers and operators.

Issue for Analysis

The application and use of Closed Containment Aquaculture (CCA) and Recirculating Aquaculture Systems (RAS) to address the economic and environmental interests of First Nations.

Applicable Region

CCA and RAS are anticipated to be applicable to all regions in Canada. Issues with respect to the impact of extreme temperature environments need to be studied.

Applicable Fisheries

This technology may be applicable wherever closed containment systems are utilized including salt water and freshwater aquaculture.

What Needs to be Studied?

There are a number of recent developments in the use of CCA and RAS; however, much of the technology is proprietary. Investigation into the applicability by climatic region and understanding the potential benefits will require engagement with system suppliers and operators. The issue of the use of CCA and RAS was a broad objective of the National Aquaculture Strategic Action Plan Initiative (NASAPI) and CCFAM Strategic Management Committee on Aquaculture (SMC).

Issue for Analysis

Identify principal areas of risk associated with CCA and RAS, and appropriate mitigation strategies. This includes, but not limited to, environmental and business risk management.

Applicable Region

CCA and RAS appear to be promising technologies. However, investigation is required to assess environmental and business risk management issues. In short; will CCA and RAS systems work in the various regions of Canada, including the north, and will they allow for profitable growing of fin fish? The Food and Agriculture Organization of the United Nations (FAO) identified the principal areas of risk faced by the aquaculture industry farmer in the pursuit of profitability. They are separated into the following categories:

Business Risks

Risks directly related to the business of producing aquatic animals and plants. Business Risks include, but are not limited to:

- **Operational Risks:** Risks which interrupt the production cycle, such as mechanical failure, failure of technical processes, late delivery of supplies and services.
- **Technological Risks:** Risks associated with lack of adequate technology, such as hatchery propagation, or lack of technical information and expertise.
- **Financial Risks:** Risks due to government financial policies, use and dependence on government policy instruments, terms of credit, and changes in operational costs.
- **Social Risks:** Risks due to actions of special interest groups, such as environmentalists and conservationists.
- **Market-Related Risks:** Risks due to loss of product quality, lack of market information, and actions of a third party (the marketing middleman)
- **Consumer-Related Risks:** Risks due to loss of consumer appeal, health regulations, and actions of a third party (the consumer).

Pure Risks

Risks of life and business in general Pure Risks include, but are not limited to:

- **Physical Risks of Nature:** Risks due to extreme climatic and meteorological conditions (for example temperature extremes, wind, flood, drought and earthquakes)
- **Social and Political Risk:** Risks due to theft, malicious damage, and fraud
- **Liability:** Risks due to legal actions

Applicable Fisheries

CCA and RAS is potentially applicable to all fin fisheries and all climatic regions in Canada.

What Needs to be Studied?

The CCA and RAS have significant potential in addressing First Nation concerns. However, intensive study is required to assess the risks associated with implementing the use of CCA and RAS. Of all the issues with CCA and RAS, understanding the risks is potentially the most critical with respect to decision-making for implementation and operations.

Issue for Analysis

Identify and review external certification programs (non-CFIA or DFO) that may improve social license for the industry and assess the potential for such programs to increase export and growth.

What Needs to be Studied?

Many certification programs have sprung up in recent years that impact the Canadian aquaculture industry including, but not limited to; Best Aquaculture Certification Program (BAP), The Aquaculture Stewardship Council, Global GAP, Canadian Organic Products Regulation (2009), Global Food Safety, and ISO 14001 (EMS). The objective of the study is to determine which certification programs provide the greatest, if any, advantage to First Nations Aquaculture.

Issue for Analysis

Promote benchmarking associated with land-based aquaculture systems. How do we know we are successful? The challenge is to identify acceptable metrics and performance reporting systems for understanding successful aquaculture across regions and internationally. The Kuterra - 'Namgis Land-Based Atlantic Salmon Recirculating Aquaculture System Pilot Project is a commercial facility reporting the technological and commercial viability of a land-based closed containment recirculating aquaculture system. Kuterra has prepared several reports with selected key performance metrics which have been accepted by its funding partners.

Applicable Region

This is applicable to all regions of Canada.

Applicable Fisheries

This is applicable to saltwater and freshwater finfish.

What Needs to be Studied?

The objective of study will be to develop a summary of performance metrics that can be applied across the First Nations aquaculture sector to measure performance.

Issue for Analysis

The benefits of pathogen reducing technologies (e.g., UV, ozone and filtration) in closed-containment facilities need to be reviewed. Effective deployment of any pathogen disinfection technology needs to first identify critical control points. These include identifying where pathogen movement is occurring (i.e., influent or effluent stream) and a risk assessment of what pathogens or diseases actually require mitigation.

Applicable Region

This is applicable to all regions of Canada.

Applicable Fisheries

Any fisheries that can use CCA systems.

What Needs to be Studied?

Researchers and operators are identifying positive results from innovations in water filtration systems which have partially reduced the need for active disinfectants. Recent reports from operators credit drum filtration for reducing bio fouling and operating costs while improving fish health. In addition, researchers at DFO and Nofima have recently announced diagnostic tools for assessing diseases in early stages which may help avoid costly cross contamination.

Section 3

Natural Marine Environment Systems

Issue for Analysis

Production of sterile farmed salmon. Technologies that ensure farmed salmon do not change the genetic characteristics of wild salmon exist. It is necessary to develop alternative and improved technology for producing sterile farmed salmon.

Applicable Region

This is applicable to east and west coasts.

Applicable Fisheries

This is applicable to open pen salmon farming.

What Needs to be Studied?

After 10 years of research Nofima scientists have finally “cracked the code” to produce sterile farmed salmon. Inducing sterility in farmed salmon will make them unable to interact genetically with wild salmon populations. The applicability of producing sterile salmon needs to be reviewed.

Issue for Analysis

Identify technologies that reduce negative impacts due to transfers of aquatic organisms. When salmon reach the age to be transferred from freshwater to sea water, about 10 percent will die due to stress-related opportunistic infections. This represents \$400 million in lost revenue globally.

Applicable Region

This is applicable to east and west coasts.

Applicable Fisheries

This is applicable to salmon farming.

What Needs to be Studied?

New research suggests preen oil extracted from chickens has benefits as an anti-inflammatory and as a health and growth booster. It is particularly effective when administered to smaller fish. Review findings to date and determine steps for implementation into Canadian Aquaculture.

Issue for Analysis

Document the performance of diffused aeration and pure oxygen systems for large-scale marine applications. Identify advantages, costs, and benefits. This issue was originally raised by the Canadian Science Advisory Secretariat.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to finfish rearing.

What Needs to be Studied?

Research and development in recirculating systems has been ongoing for nearly four decades. There are many alternative technologies for each process and operation. The selection of a particular technology depends upon the species being reared, production site infrastructure, production management expertise, and other factors. Prospective users of recirculating aquaculture production systems need to know about the required water treatment processes, the components available for each process, and the technology behind each component.

Issues for Study:

- Review the initial work completed by the Canadian Science Advisory Secretariat and any follow-up to their Science Advisory Report 2008.
- Create an inventory of diffused aeration and pure oxygen systems models and the suppliers who provide and operate them.
- Identify standard key performance indicators for this function and review any performance reports available.
- Contact providers of the most widely used systems and assess their practical application for specific regions in Canada.

Issue for Analysis

Conduct research in the field of floating flow-through bag systems to determine if past mechanical, material and structural failures can be overcome.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to finfish rearing.

What Needs to be Studied?

AgriMarine Technologies Inc. in Comox, BC was contracted by the BC government in 2000 to find a solution to escape, disease and pollution problems common to traditional net pen farms. AgriMarine developed a self-contained package that includes 12 tanks, each 24-meters in diameter and 6.1 meters deep. Circulating water that is completely replaced every hour provides a semblance of ocean currents that improves flesh quality, while removing fecal matter and unconsumed feed.

Issues for Study:

- Follow-up is required to review the performance of the AgriMarine Technologies floating system to establish a baseline for potential future operations;
- Create an inventory of the models and the suppliers who provide and operate the systems. Identify standard key performance indicators for waste removal.
- Contact providers of the most-widely used systems and assess their practical application for specific regions in Canada.

Issue for Analysis

The energy efficiency of floating flow-through systems is sensitive to pumping head and pump efficiency. An engineering analysis should be done on how to design and maintain optimum performance and reliability. The performance of existing low-head high-volume pumps for marine use should be documented.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all finfish rearing.

What Needs to be Studied?

Etec of Columbia has focused its services and products on high volume water management and availability for finfish rearing. Specifically, it's aquaculture division has focused on the movement of large water volumes at low heads, with highest efficiency.

Issues for Study:

- Review the performance of the Etec water pump systems to establish a baseline.
- Create an inventory of the models of and the suppliers who provide and operate Etec water pumping systems
- Identify standard key performance indicators..
- Contact providers of the most widely used systems and assess their practical application for specific regions in Canada.

Issue for Analysis

Technologies specifically related to predator control / management in net pens.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all finfish rearing.

What Needs to be Studied?

Birds, fish and mammals are known predators of fish reared in open pens. Bird predation is a major source of fish loss at aquaculture facilities. Predatory fish can also be a major concern to fish stocks, followed by mammal predation to a much lesser extent. Resolving bird depredation is complicated due to the variety of bird species and their unique behaviours. Many birds that feed at aquaculture facilities are also protected. A great deal of literature exists on this subject, mostly from US jurisdictions and Alberta.

Issues for Study:

- Conduct a literature review to create an inventory of current methods and assess their application to Canada.
- Conduct an operator-focused survey for each region to identify and assess the performance of anti-predation measures and innovations.

Issue for Analysis

Biofouling is one of the most significant challenges of aquaculture in the marine environment. Refine technologies specifically related to biofouling control in shellfish net pens. Studies by Finnish and Australian researchers have found that as much as 30% of the final retail value of shellfish has been attributed to anti-fouling (AF) measures. The aquaculture industry is under an environmental microscope. Given the toxicity of most AF measures (e.g. lead and zinc based marine paint), many of these measures from other marine industries are not acceptable for use in aquaculture.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all net pen applications.

What Needs to be Studied?

Exploring new anti-fouling (AF) technology is a challenging area to explore because: major marine industry players have significant R&D investments in AF that must be recouped. Effective AF technology provides significant competitive advantage for its owners and may be kept secret. Biofouling and AF technology is very complex and requires thorough knowledge of the field. In general terms, the most current scholarly articles indicate the mechanical removal of biofouling, coupled with copper coatings on fish nets is “the only consistently effective form of biofouling prevention.”

Issues for Study:

- Review the most recent articles related to AF and establish contact with suppliers of the most promising technology.
- Obtain performance data for each technology, observe its performance in the field to the extent possible and determine its applicability to Canadian operations.

Issue for Analysis

Develop methods to improve mort disposal (e.g. generation of alternative revenue streams such as composting).

Applicable Region

This is applicable to all regions in Canada.

Applicable Fisheries

This is applicable to all finfish rearing.

What Needs to be Studied?

AgriMarine Technologies Inc. of Comox, BC has developed a self-contained tank system where circulating water is completely replaced every hour providing a semblance of ocean currents. This improves flesh quality while removing fecal matter and unconsumed feed. In the circulation tank the motion flushes out the waste, which is recycled for compost.

Issues for Study:

- Review the performance of the AgriMarine Technologies floating system to establish a baseline for performance.
- Create an inventory of the models and the suppliers who provide and operate the tank systems.
- Identify standard key performance indicators for this function and review any performance reports available.
- Contact providers of the most widely used systems and assess their practical application for specific regions in Canada.

Issue for Analysis

Develop improved technologies for identifying and tracking toxic algae blooms to prevent the interaction of blooms with fish in net pens.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all finfish rearing.

What Needs to be Studied?

The U.S. Geological Survey announced a joint collaboration between EPA, NOAA, NASA, and USGS scientists which demonstrated that satellite imagery can be used to track the frequency of harmful algal blooms. The satellites can accomplish this by measuring certain algal pigments in the water.

Issues for Study:

- Investigate the use of satellite imagery technology for tracking algae blooms and how this may assist finfish aquaculture.

Issue for Analysis

Develop efficient means to oxygenate waters in net pens.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all finfish rearing.

What Needs to be Studied?

There is potential opportunity to improve fish rearing by infusing pen water with oxygen. The technology has improved significantly in recent years with the advent of computer controlled water content diagnostics and metering. This allows micro and macro adjustments in real time.

Issues for Study:

- Contact leading Canadian suppliers of water aeration services to inventory their latest products and review performance.
- Compare these findings with results from operators' surveys regarding their preferred oxygenation processes and systems

Issue for Analysis

Develop a tool for economic modelling for IMTA with various species: primary (e.g., finfish), secondary (e.g., shellfish) and tertiary (e.g., marine plants) aquaculture products. Evaluation of IMTA to address, among other things, overall environmental performance, including life-cycle analysis of entire IMTA operations.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all finfish rearing.

What Needs to be Studied?

IMTA sites are testing the sustainability and economic effectiveness of this model. Visit IMTA sites to review results and develop standard performance indicators that will allow comparison with non-IMTA control.

Issue for Analysis

Review performance of 4 different non-medicinal methods of removing sea lice:

- Flusher (FLS-)
- Thermo (Thermolicer/Optolicer)
- Freshwater (Bath)
- Bio action (Cleaner fish)

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all finfish rearing.

What Needs to be Studied?

Several industry suppliers provide de-licing solutions. Marine Harvest R&D labs in Norway have been experimenting with these methods.

Issues for Study:

- Review the performance documentation currently available on de-licing and contact Marine Harvest R&D labs in Norway to assess current state of development of each method.
- Identify and interview other providers of de-licing technology and provide recommendations for implementation into Canada.

Issue for Analysis

Investigate the initial results of closed marine systems including:

- Egg
- Donut
- Repurposed ship

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all finfish rearing.

What Needs to be Studied?

The design of closed marine pen structure is rapidly evolving. Researchers are looking for ways to mitigate negative effects of open penned farmed fish in marine environments. Marine Harvest R&D Labs Norway has identified three designs for experimentation.

Issues for Study:

- Review all documentation available on closed containment systems. As well, contact Marine Harvest R&D Labs in Norway to discuss the current economic and technical feasibility of the three systems

Issue for Analysis

Investigate potential for using eggs of northern finfish as input to east/west smolts.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all finfish rearing for species from the north.

What Needs to be Studied?

There may be a linkage between cold temperature environments of northern fish and the success of their eggs in smolt production in CCR operations.

Issues for Study:

- Identify and contact the Quebec firms which use eggs from Yukon river fin fish. Review their experience and determine, if possible, suitability of implementation in other regions. Also examine potential to expand egg harvest from Yukon supplier.

Section 4

General Aquaculture Issues

Issue for Analysis

Investigate innovative tools to provide early diagnosis of disease with finfish and shellfish species.

Applicable Region

This is applicable to all of Canada.

Applicable Fisheries

This is applicable to all finfish and shellfish rearing.

What Needs to be Studied?

Department of Fisheries and Oceans (DFO) has a molecular viral disease diagnostic panel.

Issues for Study:

- Investigate practical applications of DFO's molecular viral disease diagnostic panel for finfish and shellfish.

Issue for Analysis

Review opportunities to adopt green technologies to improve waste management, energy use, water consumption, and recycling in aquaculture operations. Several industry leaders have created innovations for reducing waste and reusing waste for energy production. Results are rarely shared as these innovations create effective competitive advantages for fish farmers.

Applicable Region

This is applicable to all of Canada.

Applicable Fisheries

This is applicable to all freshwater and saltwater fisheries.

What Needs to be Studied?

Mike Meeker of Meeker's Aquaculture has invested in a number of fish farming innovations, including a compost program, in an effort to harvest the gas produced during decomposition and use it as green energy.

Issues for Study:

- Innovations in using green technology need to be investigated for their applicability and sustainability for the finfish sector.

Issue for Analysis

Evaluate technologies to enhance shellfish depuration in British Columbia. Depuration helps remove or reduce fecal bacterial contaminants from shellfish but is ineffectual in removing viral contaminants such as norovirus and hepatitis A. It is not consistently effective, or is ineffective, in removing other contaminants such as naturally occurring marine vibrios (e.g. *Vibrio parahaemolyticus* and *Vibrio vulnificus*), marine biotoxins (such as those causing paralytic shellfish poisoning PSP, diarrhetic shellfish poisoning DSP and amnesic shellfish poisoning ASP) or heavy metals or organic chemicals.

Applicable Region

This is applicable to all of Canada.

Applicable Fisheries

This is applicable to all shellfish aquaculture.

What Needs to be Studied?

Literature reviews suggest the most promising new technologies related to shellfish depuration involve early diagnosis and identification of specific contaminants within shellfish environments.

Issues for Study:

- Conduct a comprehensive literature review on the subject to create an inventory of depuration technologies and techniques in use internationally. Review the range of options with a specific intent of identifying those techniques which have the best performance and may be applicable.

Section 5

Aquaculture Economics

Issue for Analysis

Investigate requirements for access to CFIA inspection services in the north and options to address gaps in service. Having access to CFIA services is critical. Presently, CFIA inspection services are not available in a number of locations in the north.

Applicable Region

This is applicable in northern Canada.

Applicable Fisheries

This is applicable to all fish production facilities.

What Needs to be Studied?

Lack of consistent and timely access to CFIA inspectors has been identified as one reason why previous efforts to establish commercial fisheries in the north have failed. New inspection and verification technologies, as well as improved inspection infrastructure and travel options may have increased CFIA accessibility to northern regions.

Issues for Study:

- Identify and assess the impacts of potential gaps in service. Identify strategies or requirements to address the service deficiency.
- Contact CFIA regional operation teams and confirm inspection requirements and location of CFIA resources for individual regions and aquaculture operations.

Issue for Analysis

There are many opportunities for increasing products and revenue from aquaculture operations by using marine plants.

- seaweed extract fertilizers;
- kelp meal for feed supplements and soil amendments;
- edible sea vegetables;
- seaweed ingredients for food, health and beauty markets;
- commercial brewing agents; etc.

Applicable Region

This is applicable to all regions in Canada.

Applicable Fisheries

This is applicable to all freshwater and saltwater operations.

What Needs to be Studied?

This initiative was identified through the Canadian Council of Fisheries and Aquaculture Ministers (CCFAM) Strategic Management Committee on Aquaculture and the National Aquaculture Strategic Action Plan Initiative (NASAPI) round tables.

Issues for Study:

- Conduct a comprehensive assessment of markets, biophysical resources, production technologies, and financial viability for cultivation of marine plants for use in byproduct production.

Issue for Analysis

Support innovation to address the need for mechanical shellfish handling (i.e. grading, resetting stock post-overwintering, etc.), harvesting and processing technologies. As part of its 2010 strategic planning program, the Pacific Shellfish Institute of Olympia, Washington set a goal to establish a “library of processing, seafood handling, and value added developments to be maintained by PCSGA/PSI...” Specific Strategies/Activities include:

- Identify optimal design and materials of harvest implements and mechanical equipment.
- Mechanical Clam Harvesting—continue research on the use and development of mechanical clam harvesting technology.
- Alternative materials for Geoduck farming – currently farmers are using PVC tubes for predator control which are expensive and labor intensive. Research is needed into alternative methods and materials to make the process more cost effective.
- Research ergonomic devices oriented towards reducing harvest-related wear and tear.
- Research ways to reduce work related injuries and related costs.

Applicable Region

This is applicable to the east and west coasts.

Applicable Fisheries

This is applicable to all shellfish fisheries.

What Needs to be Studied?

The Pacific Shellfish Institute has been developing a library of information. As well, shellfish producers have been developing new technologies and processes.

Issues for Study:

- Discuss with the Pacific Shellfish Institute their progress on development of the library of processing, seafood handling, and value added developments
- Visit shellfish producers with new technologies to investigate which new processing techniques for value added products, as well as new equipment and innovative technologies for production and handling techniques, may be applicable to Canada.

Issue for Analysis

Conduct a comprehensive review of the non-proprietary strains of Atlantic salmon and steelhead, and establish an initiative to enhance productivity and sustainability in the sector. This initiative was identified through the Canadian Council of Fisheries and Aquaculture Ministers (CCFAM) Strategic Management Committee on Aquaculture and the National Aquaculture Strategic Action Plan Initiative (NASAPI) Round Tables.

Applicable Region

This is applicable to the east coast of Canada

Applicable Fisheries

This is applicable to finfish production.

What Needs to be Studied?

The opportunity to utilize non-proprietary strains of Atlantic salmon and steelhead to enhance productivity and sustainability in the sector.

Recommendations

In Canada, there is no single repository of information regarding innovation and technology in the aquaculture sector. This lack of information creates a barrier to First Nations wishing to enter the industry and also impacts existing operators who wish to evaluate and implement new technologies and innovations.

This report is the first step towards improving access to leading-edge technologies and innovations for First Nations aquaculture in Canada by:

- Identifying and prioritizing the most relevant issues of innovation and technology in aquaculture, and;
- Providing a list of issues for additional investigation with the ultimate objective being the development of a compendium of information on innovation and technology.

For further information contact:

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