Fisheries and Oceans Canada | Pêches et Océans Canada

Aquaculture Management Division | Division de la gestion de l'aquaculture
Director | Directrice

Pacific Region | Région du Pacifique

August 5, 2022

Email subject Line: Registration for Summer 2022 Engagement on development of an Open-Net Pen Transition Plan

Last week the Minister of Fisheries, Oceans and the Canadian Coast Guard, the Honourable Joyce Murray, announced the release a discussion framework which outlines the vision for open-net pen transition in British Columbia. It will be used to guide engagement and consultation with the Province of British Columbia, First Nations, industry and British Columbians on the development of an Open-Net Pen Transition Plan in British Columbia (B.C). Over the coming months, Fisheries and Oceans Canada will engage on this framework through virtual and in-person formats, such as workshops, bilateral meetings, and an online public consultation survey. Details of each phase of engagement and consultation are provided below.

August 2022 Engagement Opportunities

Fisheries and Oceans Canada would like to invite you or representatives of your organization to attend an upcoming virtual engagement information sessions on the Transition Plan. The first engagement sessions will be held in August 2022 and different sessions will be open to all interested First Nations communities, Indigenous organizations in B.C., industry, local governments, and environmental non-governmental organizations. We encourage you to share the engagement participation information to other interested representatives or groups.

- Pre-Presentations – Review of aquaculture regulatory regime in B.C. and current state of knowledge on aquaculture operations.
  - Thursday August 11: 1-3pm PST (option 1)
  - Friday August 12: 1-3pm PST (option 2)
- Overview Session - Information on the mandate, previous reports, draft framework, and engagement plan.
  - Friday August 19: 10:30am-12:00pm PST
- Framework Workshop – Review draft framework and discuss questions within the document.
  - Thursday September 1: 1-4:00pm PST

Please RSVP at DFO.PACAquacultureEngagement-EngagementdelaquaculturePAC.MPO@dfo-mpo.gc.ca with your preferred dates and times for each of the sessions.

If you are unable to attend the sessions on the above dates, we will hold workshops in September and additional engagement and consultation throughout Fall 2022. An email will be sent out early September with more information on fall engagement plans and opportunities to get involved.

Online Public Consultation

Public consultation on the Open-Net Pen Transition Plan provides an opportunity for British Columbians, including First Nations and the aquaculture industry, to provide their views on the future of aquaculture in British Columbia.

The web consultation survey will be available shortly and will be open until early September 2022. The survey will be available here: Consultations and engagement | Pacific Region | Fisheries and Oceans Canada (dfo-mpo.gc.ca)

Engagement and Consultation Plans

Additional engagement and consultation will take place through 2022 and 2023. The phases of engagement are as follows:

Phase One (Late July – September 2022)
Phase one focuses on information sharing and initial input on the Framework through virtual workshops and online consultation.

Phase Two (September – December 2022)
Phase two will provide opportunities for detailed dialogue and the exchange of ideas through workshops, roundtables, and meetings. In this phase, more detailed information will be presented which will look at recommendations for inclusion in the final Transition Plan.

Phase Three (January – March 2023)
Phase three will be available for all interested First Nations who want to continue their dialogue with DFO to ensure that they are thoroughly engaged and consulted in discussions related to potential outcomes of a Transition Plan. This phase will also ensure that all stakeholder groups have the opportunity to hear and respond to the input of other groups.

Phase Four (March – June 2023)

Phase four will be a continuation of consultations, but more focused on addressing specific concerns and that perspectives are meaningfully considered in drafting the final Transition Plan.

We look forward to working with you on the future of aquaculture in British Columbia.

Sincerely,

Aquaculture Management Division | Division de la gestion de l'aquaculture
Fisheries and Oceans Canada | Pêches et Océans Canada
Government of Canada | Gouvernement du Canada
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Government of Canada launches engagement towards a plan to transition from open-net pen salmon farming in British Columbia

From: Fisheries and Oceans Canada

News release

July 29, 2022

Vancouver, British Columbia - In order to advance innovation and support the ecological sustainability of the aquaculture sector in British Columbia, Fisheries and Oceans Canada is taking the next step to transition from open-net pen aquaculture in British Columbia coastal waters. The transition will require a strong plan that outlines how to proceed, in a way that greatly minimizes or eliminates risk to wild salmon, while also taking into account social, cultural and economic factors.

To that end, the Minister of Fisheries, Oceans and the Canadian Coast Guard, the Honourable Joyce Murray, today released a discussion framework which outlines a proposed vision for open-net pen transition in British Columbia. The Minister also launched the next round of stakeholder engagement on the future of the aquaculture sector in British Columbia. This will build on previous engagement undertaken by the Department in 2020 and 2021 and takes into account the evolution of aquaculture management in response to emerging science and research.

The proposed Framework and engagement approach will help guide the engagement with the Province, First Nations, industry, conservation organizations, and British Columbians, and take into account diverse views on aquaculture. Over the coming months, Fisheries and Oceans Canada will gather input through roundtables with Indigenous leaders, local governments, key stakeholders, and conservation organizations; bilateral meetings with First Nations and provincial governments; consultations with First Nations; the aquaculture industry and key stakeholder leaders; and online public engagement. Information received during these sessions will help shape a transition plan built on four objectives:

- Create a pathway for existing aquaculture operations to adopt alternative production methods that minimize or eliminate interactions between farmed and wild salmon;
- Improve transparency on how the government assesses and responds to new scientific information to build confidence and trust in how aquaculture is managed;
- Provide greater opportunities for collaborative planning and decision-making with First Nations partners; and,
- Advance innovation and attracting investment to support the adoption of alternative production technologies in British Columbia.

The input and feedback received during these engagement sessions will be instrumental in the development and implementation of the open-net pen transition plan, expected to be finalized in Spring 2023.

Quotes

> “Wild Pacific salmon are at risk of disappearing forever if we don’t act; that’s why the Government of Canada is taking a wide range of actions to halt and reverse their declining population. We will continue to chart the course forward for aquaculture in British Columbia, one that will support the ecologically sustainable growth of the industry, create jobs, and help keep our waters and marine ecosystems protected. As the world’s appetite for high-quality fish and seafood continues to grow, we need to find better and innovative ways to farm fish and protect wild Pacific salmon stocks. A well-developed transition plan is the first step to growing a viable and sustainable industry in British Columbia.”
>
> The Honourable Joyce Murray, Minister of Fisheries, Oceans and the Canadian Coast Guard

Quick facts

- Global demand for seafood is increasing and the aquaculture industry in Canada produces over $1 billion in fish and seafood products every year.
- In Canada, 45 different species of finfish, shellfish, and marine algae are cultivated commercially; finfish accounts for most production and value.
- On June 22, Minister Murray announced the two-year renewal of aquaculture licences for B.C. facilities outside the Discovery Islands, in order to allow time for the development of a sound transition plan.

- The Government of Canada previously undertook engagement in 2020, 2021 and early 2022, collected views on transitioning the salmon aquaculture sector.

Related products

- Discussion Framework: Toward an open-net pen transition plan

Associated links

- As-was-heard report - Open-net pen transition plan: initial engagement process
- State of Salmon Aquaculture Technologies
- A Summary of the Indigenous and Multi-stakeholder Advisory Body (IMAB) on Aquaculture

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- Follow the Canadian Coast Guard on Twitter, Facebook, Instagram and YouTube.

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The future of salmon aquaculture in British Columbia - Toward an open-net pen transition plan: A framework for discussion

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A new framework for sustainable aquaculture in British Columbia

Wild Pacific salmon are iconic species that have high environmental and cultural value both to Indigenous peoples, and all people of British Columbia (B.C.), which are facing historic threats. The health and well-being of salmon is of great importance, and with their numbers in decline, governments and partners must take bold action to strengthen and rebuild their populations. Wild salmon are subject to many stressors which have a cumulative impact on their health, and evolving science and a precautionary approach must continue to inform the Government of Canada's understanding and management approach.

B.C.'s ocean spaces support a thriving marine-based salmon aquaculture industry, which is an important contributor to Canada's economy and food security. Aquaculture is B.C.'s largest agricultural export and its production represents 60% of Canada's total salmon production [1]. Canadians, however, have polarized views on the benefits and risks of culturing salmon in open-net pens along B.C.'s coast. A robust and evolving body of science and research continually provides new information about interactions between wild and cultured salmon.

In 2019, and again in 2021, Canada's Minister of Fisheries, Oceans and the Canadian Coast Guard was mandated to continue to work with the Province of B.C. and Indigenous communities on a responsible plan to transition from open-net pen salmon farming in coastal B.C. waters by 2025. Fisheries and Oceans Canada (DFO) has been tasked to work collaboratively with partners, including the Province of B.C., Indigenous communities and industry leaders, to develop an open-net pen transition plan. *The Future of Salmon Aquaculture in British Columbia – Toward an Open-Net Pen Transition Plan* provides a framework for engagement to meet this ministerial mandate commitment.

Over the next year, DFO will undertake a phased engagement approach which will invite First Nations, the aquaculture sector, B.C. communities, academia, and conservation organizations to provide feedback as to what should be included in an open-net pen transition plan, and to work collaboratively to shape the plan. This framework provides a proposed approach, including a scope and time frame. Each of the phases of engagement will reflect back upon the feedback which has been provided by British Columbians, while setting out additional levels of detail about what a final plan would include. By the end of the next year, a plan will be produced which will clearly define a proposed open-net pen transition for B.C.'s salmon aquaculture industry.

> This framework proposes a **vision** for the open-net pen transition plan:
>
> Advance innovation and growth in sustainable aquaculture in British Columbia that progressively minimizes or eliminates interactions between salmon open-net pens and wild salmon while also taking into account social, cultural and economic objectives.

Over the past several years, DFO has led engagement with First Nations and stakeholders to examine key topics relevant to this transition, such as fish health, the role of technology in supporting sustainable finfish aquaculture, and the role that more area-based approaches to management may offer. The vision is guided by input received from these previous engagement and reports, including the engagement conducted by former Parliamentary Secretary Terry Beech in 2020 to 2021 with First Nations, communities, interest groups, the public, and parliamentarians, and a series of round tables in the spring of 2022 with Minister Joyce Murray.

To implement the proposed vision, a transition plan will be framed around 4 objectives, which would transform the salmon aquaculture industry in B.C.:

1. **Transition from open-net pen salmon aquaculture:** For the existing marine-based salmon aquaculture industry, create a regulatory climate which will incent adoption of alternative production technology and

tools with the goal of progressively minimizing or eliminating interactions between cultured and wild salmon

2. **Trust and transparency:** Improve trust and transparency in processes which assess and respond to new scientific information, demonstrating clear and quantifiable improvement in sustainable performance, ensuring Canadians have confidence in management of aquaculture
3. **Reconciliation and Indigenous partnerships:** Support enhanced First Nations' engagement in the management of aquaculture, including through collaborative planning and decision-making
4. **Growth in B.C. sustainable aquaculture innovation:** A whole-of-government approach to attract investment and advance innovation and development of new alternative production technology systems, including closed containment, to make B.C. a global leader in innovative aquaculture, which minimizes environmental impact.

The transition plan will detail an expected and quantifiable set of metrics for type, scale and timing of results to progressively minimize or eliminate interactions between cultured and wild salmon, and transition from current open-net pen production methods. It will build upon the work that has been done to improve the environmental performance of the industry and take a strong precautionary approach alongside the Department’s efforts to restore wild Pacific salmon stocks.

Through its development and implementation, the transition plan will clearly show how government assesses the latest developments in science and how it assesses and incorporates risk into its adaptive management approach.

The Government of Canada sees this transition as an opportunity for the salmon aquaculture sector to be a leader in Canada’s blue economy, however it is important that this is done in a sustainable manner that clearly progressively minimizes or eliminates the potential for risks to wild salmon. To support reconciliation, this plan will address opportunities to enhance Indigenous engagement and participation in aquaculture management.

Engagement and consultation phases

This framework document supports the next phases of engagement and consultation on the development of a transition plan. It provides an overview of options for achieving the proposed vision, while inviting innovative contributions as consultation and engagement progresses. Consultation and engagement will be undertaken in a phased approach from late July 2022 to March 2023.

Phase 1 (Late July to September 2022)

Phase 1 focuses on information sharing and initial input on the framework through virtual workshops and online consultation. Invitations for virtual workshops will be emailed to First Nations, Indigenous organizations, Industry, conservation groups and local governments in B.C. An online survey will be open for public input through DFO Pacific Region's consultations and engagement website.

Phase 2 (September to December 2022)

Phase 2 will provide opportunities for detailed dialogue and the exchange of ideas through workshops, roundtables, and meetings. Invitations will be emailed to First Nations and stakeholders in September for participation in Phase Two focused dialogue. DFO recognizes that many First Nations throughout B.C., whether they have salmon aquaculture in their territory or not, may want to contribute to this dialogue. In this phase more detailed information will be presented which will look at recommendations for inclusion in the final transition plan.

Phase 3 (January to March 2023)

Phase 3 will be available for all interested First Nations who want to continue their dialogue with DFO to ensure that they are thoroughly engaged and consulted in discussions related to potential outcomes of a transition plan. This phase will also ensure that all stakeholder groups have the opportunity to hear and respond to the input of other groups.

Phase 4 (March to June 2023)

Phase 4 will be a continuation of consultations, but more focused on addressing specific concerns and that perspectives are meaningfully considered in drafting the final transition plan.

Further detail on engagement and consultation will be available on the DFO website. As each phase of engagement is completed engagement materials will be updated and shared with First Nations and stakeholders. This phased engagement and consultation will invite perspectives to be meaningfully considered in collaborative development of a final transition plan. Once a transition plan is finalized in June 2023, the Government of Canada intends to further engage with First Nations and stakeholders on the next phases of plan implementation.

Working together

Advancing reconciliation

The Government of Canada is committed to reconciliation with Indigenous peoples. The Prime Minister has directed Cabinet ministers to implement the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and to work in partnership with Indigenous peoples to advance their rights. The Government of Canada is aware that there are diverse views among First Nations in B.C. about how these rights intersect with future decisions about open-net pen salmon aquaculture. The Government will work with First Nations to understand their interests and priorities for a transition plan, and its implementation. This applies to First Nations historically dependent on salmon for food, social, and ceremonial (FSC) purposes, in coastal and non-coastal fresh-water territories.

The Government of Canada acknowledges that First Nations assert a right to assess and define their relationship with the aquaculture industry. For First Nations in partnership agreements with aquaculture companies, this may mean maintaining local partnerships that contribute to economic opportunities for their communities. DFO has heard that some First Nations feel it is important that they have the capacity for: aquaculture research; monitoring of aquaculture activities and of wild salmon in their territories; and a role in management. For First Nations concerned about impacts on migrating wild salmon populations, this may include science and stewardship focused engagement. These perspectives should be a part of the discussions related to development and implementation of a transition plan.

Engagement and transparency in the development of a transition plan

The Province of B.C., First Nations, local governments, industry, and other parties all have a role in the development of a transition plan. A collaborative Strategic Oversight Committee and Technical Working Group has been formed to bring DFO, the Province of B.C., and First Nations together to provide leadership in the development of a plan. Individual First Nations will have the opportunity to be engaged bilaterally throughout the process to help define how a transition plan is developed and implemented, and how it relates to their rights. Key groups such as industry and local governments will be engaged throughout the process. The input received will assure the development of a transition plan that meets the needs of all parties.

Salmon aquaculture as part of British Columbia's blue economy

Salmon aquaculture is an important contributor to the B.C. economy. The proposed intent of a transition plan is to ensure the sector causes very little or no damage to the environment, and in particular wild Pacific salmon stocks, allowing the sector to continue in a sustainable manner. Getting this transition plan right will be important for the estimated 1,650 people who are directly employed in the aquaculture industry in B.C. [2], those employed in wild salmon harvest and processing, and many more are employed in related fields, including Indigenous-owned businesses.

Salmon aquaculture provides stable and predictable year-round economic opportunities to First Nations and B.C. coastal communities. The sector is an important source of employment for First Nations, with Indigenous peoples representing approximately 30% of the labour force of the 4 largest salmon aquaculture companies [3]. A large percentage of cultured salmon is raised in areas where First Nations have some form of agreement with aquaculture operators. Such agreements have a range of benefits, from information-sharing to monetary support and job creation. Numerous Indigenous owned businesses also support the aquaculture industry, through business such as net washing, freight transport, water taxis, contracted harvest vessels, and value added processing. In a number of cases First Nations hold the tenures for the locations where aquaculture companies have licences.

Considerations for a transition plan

There are strongly held, polarized views among Canadians on the benefits and risks of open-net pen salmon aquaculture in B.C., and what should constitute a responsible transition plan. The primary imperative is to apply the best available science, and a precautionary approach, to reduce potential risk and ensure low impact and environmental sustainability. A transition plan should consider other key factors such as: environmental risks and impacts; technological development timelines and viability; new and emerging science; competitiveness and viability of the industry; social and cultural factors; community economic considerations; Indigenous knowledge; relationships between Indigenous, provincial and federal governments; and input from stakeholders.

The proposed objectives below outline bold actions that could be taken on 4 fronts: transition from open-net pen aquaculture; trust and transparency; reconciliation and partnerships, and, growth in B.C. sustainable aquaculture innovation. The remainder of this document provides a potential approach for each of these elements in a transition plan, as a foundation for engagement. Over the coming months through engagement and consultation, additional information will be incorporated into these objectives to create the proposed open-net pen transition plan.

Objective 1 - Transition from open-net pen salmon aquaculture

The first objective of a transition plan is: **Transition from open-net pen salmon aquaculture**.

For the existing marine-based salmon aquaculture industry, create a regulatory climate which will incent adoption of alternative production technology and tools with the goal of progressively minimizing or eliminating interactions between cultured and wild salmon.

Table: Strategic shift for objective 1 - Transition from open-net pen salmon aquaculture

Strategic shift	Increased sustainability of the salmon aquaculture sector
From	New and emerging science has raised a number of concerns on aquaculture-related stressors such as pathogen and disease transfer. A majority of British Columbians view open-net pen aquaculture as a risk to wild salmon and the environment.
To	An innovative and sustainable salmon aquaculture industry, supported by robust science, that demonstrates its environmental leadership and creates public confidence.
Approach	• Use of regulatory tools (e.g. licensing) to require adoption of alternative production technology for marine facilities, including closed and semi-closed containment, that progressively minimizes or eliminate interactions between cultured and wild salmon. Phase-out of a number of salmon aquaculture licences, if they do not meet new standards • Land-based facilities grow larger smolts that require less time in the marine environment to grow to market size; and/or, land-based facilities fully grow salmon and alternative species to market size • Strategic area-based aquaculture planning and management that considers wild fish interactions, migratory routes, and timelines; coordinates stocking, treatment, and fallowing; and enhances engagement of local, provincial, and First Nations governments • Robust monitoring of cultured and wild salmon for pests and pathogens associated with aquaculture activities, with clear public reporting and feedback to management and decision-making

Past engagement and research show that a transition from open-net pen salmon aquaculture to alternative sustainable production technologies requires a regulatory environment that supports innovation. A key recommendation from the Indigenous Multi-Stakeholder Advisory Body (IMAB) technical working group on salmonid alternative production technologies was to establish a permitting and regulatory framework with clear requirements, service standards and licence durations to attract investment [4]. Similarly, the *State of Salmon Aquaculture Technologies* report recommended a clear legislative and regulatory framework to support future development of production technologies; and noted that approvals for more biomass production, especially in the marine environment, may encourage growth and innovation but must be tied to requirements of higher performance of new production technologies [5]. Feedback from a variety of stakeholders and Indigenous groups urged DFO to set clear goals, and then to allow industry to find innovative ways to meet those goals.

Through previous engagement such as former Parliamentary Secretary Terry Beech's initial engagement on a transition plan, DFO has heard that investment in new technologies requires business certainty [6]. A clear and defined pathway to transition, with transparent metrics for success, is key and should involve all of those impacted, including the Province of B.C., First Nations, industry, local governments, and other stakeholders. Rather than mandating the use of specific technology, a transition plan should incentivize the adoption of new management tools that require interactions with wild salmon be progressively minimized or eliminated. The goal of this approach would be to define incremental improvements in environmental performance which would provide evidence of a move to progressively minimize or eliminate interaction between cultured and wild salmon.

One option for incenting innovation recommended by the Indigenous and Multi-stakeholder Advisory Body's Salmonid Alternative Technologies Technical Working Group report was to explore the concept of a developmental licence/tenure. Such a licensing regime would create an environment which would support the development and trialing of technologies to progressively minimize or eliminate interactions between cultured and wild salmon. Changes to the licence/tenure regime would require discussions between DFO, Transport Canada, and the Province of B.C..

A dual stream licensing approach could include the creation of a new class of enhanced performance licences, as an alternative to standard licences. For both licence types, details related to changes to a licensing regime would be explored through this engagement process. This includes consideration as to whether industry should finance innovation and technology required to meet increasingly stringent standards that progressively minimize or eliminate interactions between cultured and wild salmon. While a dual stream licensing approach is one way to address the key elements of a blue economy by prioritizing innovation and growth in sustainable marine-based technologies that raise the bar on environmental performance of the aquaculture sector, the Government of Canada remains open to alternative ideas brought forward through the engagement process.

The proposed enhanced performance licence stream would provide an incentive for companies to meet higher standards of performance to gain the security of a longer term licence. Eligibility would require operators to demonstrate the adoption of enhanced tools that would be embedded in licence conditions, and to provide additional monitoring and reporting to assess their results. This approach would create incentives for industry to invest in partnerships and new technologies, demonstrate a continual increase in environmental performance that progressively minimizes or eliminates interactions between wild and cultured fish, align with the provincial *Salmon Aquaculture Policy* through meaningful engagement with First Nations, respect existing agreements, and support the principles of reconciliation.

Operators who choose to adopt these new tools could request to have their facility licence converted to an enhanced performance licence. Operators not adopting these new tools would, by default, retain a standard licence. Under the proposed approach, standard licences would be for a shorter duration, and with each reissuance, holders of these licences would face increasingly stringent environmental and social standard requirements. Operators not able to demonstrate that they could meet the more stringent standards would see their standard licences phased out. The pace of this change could be linked to overall performance improvements demonstrated by the industry more broadly and could be tracked using a set of defined performance metrics (more specific information on performance metrics is provided below).

Options for new tools being proposed in support of enhanced environmental performance could include any or all of the tools presented in the following table.

Table: Proposed examples for new tools to support enhanced performance in salmon aquaculture

New tools	Objective

New tools	Objective
Participation in area-based production planning	A coordinated approach to cultured salmon production (stocking, grow-out, harvest and fallow periods) in an area, including coordinated sea lice treatment and disease management protocols. This approach could: • Disrupt cycles of pathogen, disease, and sea lice transmission • Progressively minimize or eliminate interactions during times of higher risk for wild salmon
Reduced overall time that cultured salmon spend in the ocean	Drive land-based technology to grow larger, healthier post-smolt salmon before transferring to marine-based facilities, and/or to culture salmon or alternative species to harvest in land-based facilities. These approaches could: • Progressively minimize or eliminate disease and sea lice transmission and the number of treatments required • Progressively minimize or eliminate interactions of cultured salmon with wild fish and marine mammals

New tools	Objective
Implementation of innovative new technologies which would progressively minimize or eliminate interactions between wild and cultured salmon, that would be measured against performance metrics, predicated on a transition from open-net pens	Drive adoption of new marine-based innovations and technologies that would minimize interactions between wild and cultured salmon, which could: • Progressively minimize or eliminate disease and sea lice transmission and the number of treatments required • Progressively minimize or eliminate interactions of cultured salmon with wild fish and marine mammals
Participation in wild salmon monitoring or enhancement programs	Salmon aquaculture industry shares responsibility in the protection of wild salmon. This approach could: • Enhance monitoring and improve data to inform management decisions • Improve understanding of effects of interactions between cultured and wild salmon • Contribute to wild salmon enhancement

New tools	Objective
Use of third party observers, to monitor activities for validated reporting	This approach could: • Enhance monitoring and improve data to inform management decisions • Improve public trust and transparency in reporting data
A requirement to secure local First Nations partnership from those within whose territories the licensed facility is situated	This approach could ensure: • Opportunities for First Nations to work with industry to set additional locally specific requirements based on Indigenous knowledge, science, preferred technologies, and other considerations • Opportunities to address local priorities through enhanced standards and management objectives

In order to assess the effectiveness of a new regulatory regime and the tools described above, DFO could require the adoption of enhanced performance metrics, which would provide more information about the level of interaction between wild and cultured fish. The implementation of more advanced and comprehensive metrics would allow government to set specific targets for industry and improve public accountability for progress of the industry’s environmental performance. It could also allow for more customized management within specific areas, based upon local environmental conditions and the interests and concerns of First Nations. The following table provides some examples of the types of metrics to consider.

Table: Proposed examples of enhancement of metrics to assess cultured salmon interactions with wild salmon and the marine environment

Metrics	Objective
Improved metrics for measuring sea lice impact (e.g. reduced abundance of sea lice, reduced time above the sea lice threshold, reduced number of treatments required), at the facility and/or area-level	Indicate reductions in transmission of sea lice and between wild and cultured salmon
Reduced incidents of cultured salmon mortality by disease or maintaining consistently low mortality by disease	Indicate minimized transfer of pathogens and disease transmission between wild and cultured salmon
Reduced number of disease outbreaks, as measured by reduced incidents of disease treatments	Indicate reduced transmission of pathogens or disease between wild and cultured salmon
Reduced incidents of cultured salmon escapes	Indicate reduced interactions between wild fish and cultured salmon

Metrics	Objective
Reduced number of wild fish (e.g. herring) within aquaculture infrastructure, or mortality events/ impacts during site handling events such as mechanical sea lice treatments of cultured salmon	Indicate reduced interactions and impacts on wild fish from salmon aquaculture activities
Reduced incidents of marine mammal and predator interactions with aquaculture facilities	Indicate reduced interactions between marine megafauna and cultured salmon

Enhanced target metrics would be set based on the best available science, with input from First Nations and stakeholders, and could vary based on coastwide or regional environmental, social, and technical factors. They could also be temporal in nature (for example, specific measurements to demonstrate performance during the wild Pacific salmon outmigration period).

In its management of the marine finfish aquaculture industry, DFO collects robust data related to the marine finfish aquaculture industry performance, and requires the collection and submission of additional information from industry. In order to assess the effectiveness of a new regulatory regime and the proposed tools described above, the use of enhanced performance metrics could provide more information about the level of interaction between wild and cultured fish at an aquaculture facility and in an area. Implementation of more advanced and comprehensive metrics would allow government to set specific targets for industry and allow DFO, as the regulator, to assess which types of enhanced performance activities are having the greatest positive impact on reducing or eliminating interactions with wild salmon.

An assessment of the new regulatory approach and industry performance would take place at regular intervals to assess progress and to determine if operators were meeting the requirements imposed upon them. The adoption of new enhanced aquaculture management tools and metrics would support a transition toward progressively minimized or eliminated interactions between cultured and wild salmon. These regulatory options are proposed in this framework for discussion and for feedback during the engagement process.

Objective 1: Discussion questions

Discussion questions on the proposed dual licensing approach

1. Would a dual stream licensing approach be a reasonable approach to promote a transition from open-net pen salmon aquaculture? If not, what other type of approach could DFO consider?
2. Would a dual stream licensing approach address issues of importance to industry, First Nations, and the stakeholders?
3. Could the proposed dual stream licensing approach move forward technology and innovation in a manner that addresses concerns about potential environmental risk?
4. DFO has heard that industry requires a longer licence duration for business certainty and investment, but has also heard that licence durations should be short to maintain a high degree of regulatory control. What do you think is a reasonable licence duration? Do you support the idea of having different licence types with different licence durations?
5. Do you think a developmental licence could be advanced to incent the development and adoption of alternative production systems and technologies in B.C.?

Tools: Discussion questions on the proposed enhanced environmental performance

1. Are the tools proposed to support enhanced environmental performance the right tools to transition B.C.'s marine based salmon aquaculture industry to progressively minimize or eliminate future interactions with wild fish and ecosystems? Are there other tools which should be considered?
2. Do the enhanced environmental performance tools allow flexibility for industry to meet the transition plan's objectives while creating better information to allow government to evaluate interactions between cultured and wild salmon?
3. Should a transition plan consider different environmental performance tools for different species of cultivated fish, for different areas and conditions?
4. Should all aquaculture sites be treated equally, or should smaller marine finfish operations or those growing species other than Atlantic salmon face less restrictive environmental performance standards?
5. What time frame would be realistic for the adoption and implementation of each of the enhanced environmental performance tools?
6. How would you like to see new enhanced environmental performance tools such as these developed? For example, if you would like to see them developed collaboratively, what form should that process take?
7. If enhanced performance licences are able to consistently meet a higher target metric, should all standard licences be adjusted to require a higher level of performance over time?

Metrics: Discussion questions on the proposed new metrics to evaluate the reduction of interactions between wild and cultured fish

1. Would the development of enhanced performance metrics help to assess concerns related to the reduction or elimination of interactions between cultured and wild salmon in a transition plan?
2. Recognizing that innovation needs to have room for both success and failure, how should performance metrics be incorporated into the licensing regime for the enhanced performance licences?
3. What specific metrics should a transition plan should consider?
4. Are there other metrics which should be considered?
5. How would you like to see new metrics such as these developed? For example, if you would like to see them developed collaboratively, what form should that process take?
6. How should metrics be measured and what should the targets be for reducing or eliminating interactions between wild and cultured fish?

Objective 2 - Trust and transparency

The second objective of a transition plan is: **Trust and transparency**

Improve trust and transparency in processes which assess and respond to new scientific information, demonstrating clear and quantifiable improvement in sustainable performance, ensuring Canadians have confidence in management of aquaculture.

Table: Strategic shift for objective 2 - Trust and transparency

Strategic shift	Improved trust, transparency, and clarity of regulatory goals and actions

From	Conflicting conclusions in the public domain foster a lack of trust in the assessment of risk and impact and the regulation/ management of the marine finfish aquaculture industry in B.C.
To	Clear goals and outcomes support a sustainable aquaculture sector in B.C. informed by a transparent and inclusive science review and assessment process, grounded in an understanding of local ecosystems (and wild salmon health), supported by world leading aquaculture science, and incorporating First Nations science and knowledge.
Approach	• Public engagement and knowledge and trust in aquaculture science and how it is used to inform management decisions • Clear metrics, developed through public engagement, clearly show progressively minimized or eliminated interactions between cultured and wild fish, and provide evidence of effective management and decision-making • Public reporting at the facility, area and coastwide scale provides clear evidence and assessment of interactions and impacts of cultured/ wild fish interactions

The Government of Canada has heard that trust represents a key area of concern in its current management of salmon aquaculture. A transition plan should address this concern and act to build better relationships between and among governments and partners to ensure that new tools, metrics, and monitoring are transparent, collaborative, and grounded in the best available science. Wild salmon monitoring and enhanced understanding of the science related to interactions between cultured and wild fish are important measurements of success in meeting the plan's goal to progressively minimize or eliminate interactions between cultured and wild salmon. By strengthening the transparency of processes for assessing and responding to new scientific information, clearly showing Canadians that regulation and management is effective, demonstrating progressively minimized or eliminated interactions between wild and cultured fish, will rebuild trust and transparency in a robust and innovative sustainable marine finfish aquaculture sector in B.C..

Objective 2: Discussion questions

Discussion questions on trust and transparency

1. What elements should be incorporated into a transition plan which will build confidence in the management of aquaculture in B.C.?
2. What steps could be taken to ensure there is broad understanding of both the science process and outcomes of research and their role in decision-making?

Objective 3 - Reconciliation and Indigenous partnerships

The third objective of a transition plan is: **Reconciliation and Indigenous partnerships**

Support enhanced First Nations' engagement in the management of aquaculture, including through collaborative planning and decision-making.

Table: Strategic shift for objective 3 - Reconciliation and Indigenous partnerships

Strategic shift	Improved engagement of First Nations communities in management and decision-making
From	Dissatisfaction of First Nations in their current role in areas in which government have authority over aquaculture management
To	Increased involvement of First Nations in aquaculture activities on their territories, including First Nations agreements required for licensing, Area-Based Aquaculture Management, and First Nations partnerships for monitoring, guardianship programs, and research and development
Approach	• Meaningful engagement with First Nations, respect for existing agreements, and support for the principles of reconciliation • Drive industry toward true partnerships with Indigenous communities by rewarding strong partnerships, supporting Indigenous Knowledge and Science, and through broader implementation of Area-Based Aquaculture Management

Indigenous peoples have spoken clearly to the Government of Canada, articulating the need to have a broad cross-section of Indigenous voices play a key role in deciding and defining the future of salmon aquaculture in B.C. A transition plan should reflect the input and interests of Indigenous peoples, coastal and non-coastal alike. It should clearly outline the manner in which Indigenous knowledge is incorporated into the management of aquaculture, and provide a framework which facilitates collaborative governance of aquaculture management in a manner that actively engages Indigenous peoples in a way that they feel best accommodates their rights, Title, and unique relationship with the Governments of Canada and British

Columbia. This holds true for First Nations with aquaculture on their territories, as well as for First Nations in whose territory salmon are born, and return to spawn.

Starting with a wide and comprehensive engagement process related to this framework, the transition plan should incorporate Indigenous perspectives and viewpoints. The transition plan should also account for collaboration with First Nations throughout its implementation.

Objective 3: Discussion questions

Discussion questions related to Reconciliation and Indigenous partnerships

1. Through engagement with Indigenous organizations and First Nations, DFO would like to hear the priorities and aspirations for an open-net pen transition plan.
    a. How can DFO effectively engage with First Nations who have finfish aquaculture in their territories?
    b. How can DFO effectively engage with First Nations who do not have salmon aquaculture in their territories, but may have concerns about the implications of aquaculture and a transition plan for issues of critical importance to them, such as healthy wild salmon populations?
2. Is an Area-Based Aquaculture Management approach a tool which would support improved engagement with Indigenous peoples in aquaculture management?
3. What are the most important steps the Government of Canada could take to move forward on this objective?

Objective 4 - Growth in B.C. sustainable aquaculture innovation

The fourth objective of a transition plan is: **Growth in B.C. sustainable aquaculture innovation**

A whole-of-government approach to attract investment and advance innovation and development of new alternative production technology systems, including closed containment, to make B.C. a global leader in innovative aquaculture, which minimizes environmental impact.

Table: Strategic shift for objective 4 - Growth in B.C. sustainable aquaculture innovation

Strategic shift	Create an environment that supports innovation in sustainable aquaculture management
From	Industry expresses frustration with and is deterred by the lengthy and complex regulatory and licensing regime that has multiple authorizations. Canada is not a desirable location for research and development or innovation in aquaculture technology.
To	Working with other federal departments and the Province of B.C., DFO improves the harmonized whole-of-government approach that supports a clear and nimble regulatory and licensing regime. This creates an environment that attracts innovation, particularly in the land-based sector.

Approach	- A stable regulatory environment that provides the industry with certainty to innovate and concise, clear licensing requirements to facilitate business development and assistance in siting and developing new land-based facilities - An innovative and collaborative industry that is responsive to the goals of open-net pen transition, attracts investment and research and development partnerships within industry and with First Nations. It fosters local and First Nations' business opportunities, and is supported by information and services to take on the business risk of innovation - A skilled and flexible workforce, that includes local and First Nations workers, that adapts with a highly innovative industry, including the addition of land-based technology

Through initial consultations, DFO has heard that investment in alternative aquaculture production, including land-based facilities, needs to be encouraged by making B.C. a more globally competitive market that fosters business confidence and drives innovation. At present, much of the innovation, research, and development in aquaculture in B.C. occurs on a project-by-project basis in an uncoordinated approach across the industry. Working collaboratively, governments should create an attractive business environment that signals Canada is committed to advancing growth in sustainable aquaculture in B.C. More clearly defined government goals for the sector would lead to an innovative and collaborative industry that attracts investment for research and development fosters local and First Nations' business opportunities, and is supported to take on business risk related to innovation.

In the coming decades, growth of the global salmon aquaculture industry is expected to come from production using hybrid systems (combination of land and marine-based and net pen production), closed containment (marine and land-based), and offshore systems. The *State of Salmon Aquaculture Technologies* report assessed the feasibility of alternative technologies and suggested that land-based recirculating aquaculture systems (RAS) and hybrid systems were the most advanced and most ready for adoption in B.C. [7]. Technological and economic feasibility are important considerations in the development of a transition plan.

The land-based aquaculture sector is demonstrating potential and is considered by some investors to be a key part of the industry's sustainable future. There is an opportunity for B.C. to be on the leading edge of a future land-based aquaculture sector. Abundant freshwater, clean power and proximity to Asian and United States markets are features that could make B.C. attractive for investment in the land-based industry. Challenges to growth of the land based sector include high startup and capital costs for infrastructure, and the current state of technology and whether it can be proven at a large scale. One objective of a transition plan should be to help draw investment into research and development and new businesses. This could make B.C. a global leader in innovative sustainable aquaculture technology adoption, with the goal of developing a robust new alternative production and closed-containment sector, including the construction of new land-based aquaculture facilities in more B.C. communities.

DFO has heard that the most important factor for attracting investment is regulatory clarity and certainty. Encouraging investor confidence in the stability and future potential of the aquaculture industry in Canada will be key to attracting investment. DFO would collaborate with the Province of

B.C. and other federal departments to establish a strong yet nimble regulatory regime that would open the door to investment and innovation in new land-based closed containment aquaculture production.

There is potential for a transition plan to support investment in a broader range of sustainable aquaculture products in B.C. This could include alternative finfish species, as well as shellfish and marine plants. To provide opportunities for the sector to further diversify, the Government of Canada should work with the Province of B.C., First Nations, and industry to support product and market development of these species. A transition plan would lead the development of a stable regulatory environment that provides industry with certainty to innovate and clear licensing requirements to facilitate business development, for all sustainable aquaculture products.

Throughout previous engagement, advocates for adoption of land-based closed containment technology have underscored the importance of maintaining jobs and economic opportunities in B.C. DFO has also heard from both the land and marine-based sectors that a lack of capacity related to salmon aquaculture goods, services, and expertise, would have a significant negative impact on the development of a land-based sector. They have advocated for a planned transition of existing capacity to allow these businesses to exist through the transition.

Other potential incentives include DFO working with the Province of B.C. and other government departments to explore the use of existing or enhanced tools to attract investment into land-based and other forms of sustainable aquaculture throughout the province. Governments could: facilitate entry for those wanting to invest in the industry; support growth of sector capacity; reduce regulatory barriers; support investment in alternative aquaculture technology research and development; consider working with other partners in development of a Centre of Expertise; or provide training and employment supports to build the necessary skills to support adoption of new technology. New supports could provide better information on funding opportunities related to innovative research, purchase and installation of new technology, recruitment and training to maintain a highly skilled employee pool and other incentives.

Objective 4: Discussion questions

Discussion questions on growth in B.C. sustainable aquaculture innovation

1. Is B.C. an attractive destination for investment in land-based aquaculture?
2. Within a transition plan, what activities or actions would best support collaborations (a) within industry and (b) between different groups to advance investment in alternative production aquaculture projects, including closed containment?
3. What activities or actions would best support research and development, and adoption of new sustainable aquaculture technologies?
4. How can government, through incentives or regulation, best foster a culture of innovation to support advancement of new alternative production aquaculture technologies?
5. How should the transition plan support sustainable aquaculture production of alternative finfish species, shellfish, and marine plants?
6. Would your company, organization, or First Nation participate in or benefit from the development of a Centre of Expertise for sustainable aquaculture technology? How?
7. What areas of focus would make a Centre of Expertise most beneficial?
8. What are the workforce needs for transitioning the industry toward alternative aquaculture production? What types of worker training and

reskilling/upskilling programs are required to meet such needs?
9. What is a reasonable timeframe for a transition to adoption of sustainable alternative aquaculture technologies in B.C.?

Key milestones in the salmon aquaculture transition

Under the guidance of a transition plan, DFO proposes to incentivize a continual improvement in sustainable salmon aquaculture, while supporting B.C.'s aquaculture industry to become the most sustainable in the world. The transition plan should create the conditions to encourage the growth of a new sector of the industry that uses cutting edge alternative production technology, including both land-based closed containment and innovative advancements in technology in the marine environment that demonstrate the ability to progressively minimize or eliminate interactions between cultured and wild salmon.

Under the proposed transition plan approach, regulatory requirements related to performance for salmon aquaculture facilities would continually be raised, and focused on clear goals and transparent tracking of performance. Success would be determined using the application of tools and metrics described in this framework and as further defined based on feedback received through the engagement process.

Facilities that do not innovate, and which fall behind the overall performance of the industry would have their licences phased out. A responsible transition should provide for improvements in performance while supporting associated infrastructure and the local goods and services industry which supports the aquaculture sector.

An assessment of the progress associated with a transition plan, and any required updates to the approach, would take place at regular intervals throughout implementation of this approach. These reviews would evaluate the progress of industry performance and assess the baseline for performance and corresponding regulatory requirements. This should expedite the transition to either alternative marine or land-based tools and technologies, while maintaining its workforce and supporting industries, and while reducing the risk of economic losses in communities.

Next steps

In the summer and fall of 2022, DFO will engage on this transition plan framework for discussion. The input received will inform the delivery of an open-net pen transition plan by June 2023 with consultation on its implementation in the summer/fall of 2023. The transition plan should aim to position B.C. as a leader in alternative aquaculture production technologies and create economic development and growth in the sustainable aquaculture sector. Once a transition plan is finalized, the Government of Canada will collaborate and engage with the Province of B.C., First Nations, local governments, industry, and other parties on its implementation. In combination with an innovative marine-based sector, the development of opportunities in the land-based sector or other sustainable options will strengthen and diversify the aquaculture industry and support long-term growth of sustainable aquaculture in B.C..

Footnotes

1 Farmed salmon, Fisheries and Oceans Canada (2017).

2 Fisheries and the Canadian Economy. Employment, Fisheries and Oceans Canada (2021).

3 Minister of Agriculture's Advisory Council on Finfish Aquaculture (2018) - Gov B.C. (English only)

4 Salmonid alternative production technologies technical working group report, Fisheries and Oceans Canada (2020)

5 *State of Salmon Technologies*, Gardner-Pinfold (2019)

6 Open-net pen transition plan: Initial engagement process As-was-heard report, Fisheries and Oceans Canada (2021)

7 *State of Salmon Technologies*, Gardner-Pinfold (2019)

Date modified:

2022-07-29

Open-net pen transition plan in British Columbia: initial engagement process

As-was-heard report
December 14, 2020 – April 13, 2021

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

Letter from the Parliamentary Secretary

With warming waters and declining biodiversity in our oceans, action to support the health of our marine ecosystem is needed now more than ever. This means developing sustainable approaches to the use of ocean resources and spaces that prioritizes conservation and protection while also supporting the many coastal communities that depend on them. In British Columbia (BC), we have clearly heard the need for a more sustainable approach to aquaculture, and the imperative to protect and restore wild Pacific salmon.

The Minister of Fisheries, Oceans and the Canadian Coast Guard was mandated by the Prime Minister to:

> "Work with the province of British Columbia and Indigenous communities to create a responsible plan to transition from open net-pen salmon farming in coastal British Columbia waters by 2025…"

The Minister asked that I engage with affected First Nations, communities, aquaculture industry leaders and stakeholders, interested environmental organizations, and parliamentarians to inform our approach in British Columbia moving forward. In addition, we invited academics, industry workers and suppliers, and members of the international community to participate as well. We made sure that every person who wanted to present to the panel had an opportunity to do so. Over the course of the last number of months we spoke to 114 participants and received over 5,400 written submissions. I offer my sincerest thanks to all who participated and hope that you will find your views well represented in this report. I would also like to acknowledge the Province of BC who joined the roundtables as an observer and Fin Donnelly, BC's Parliamentary Secretary for Fisheries and Aquaculture, who participated in every session.

This interim report covers what we heard over the course of the engagements. These are provided on a non-attributed basis to protect the participants and allow everyone to speak freely. We felt it was important that any readers of this interim report see the full range of views that were presented. As this is a "what we heard report," a full analysis of viewpoints raised during the engagements was not undertaken. All notes and submissions will be made available on an attributable basis to help inform the next stage of consultations, which has received $20 million in funding through Budget 2021.

When I was first appointed as Parliamentary Secretary to the Minister of Fisheries and Oceans in 2017, the first two documents I read were the 2005 Wild Salmon Policy and the 2012 Cohen Commission Report. Each of these documents significantly engaged British Columbians and examined key issues with regard to wild salmon and finfish aquaculture. Each of these documents is still extremely relevant today.

The Wild Salmon Policy was developed over a period of five years and has four guiding principles that are still in place today:

1. That the conservation of wild Pacific salmon and their habitats is the highest priority in resource management decision-making;
2. That resource management processes and decisions will honour Canada's obligations to First Nations;
3. That resource management decisions will consider biological, social, and economic consequences, reflect best science including Aboriginal Traditional Knowledge, and maintain the potential for future generations to meet their needs and aspirations; and
4. That resource management decisions will be made in an open, transparent, and inclusive manner.

There was unanimity in our consultations that the government must do everything in its power to protect and restore wild salmon populations in British Columbia. The government's historic $647 million investment in wild Pacific salmon in Budget 2021 should go a long way in ensuring that we can deliver on the promise of the Wild Salmon Policy.

Further, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) has already been passed into law, both federally and provincially in BC. Our government is committed to a nation-to-nation relationship with the Indigenous peoples of Canada, and there is no path forward for aquaculture without meaningful involvement of BC First Nations.

Following its establishment in 2009, the Cohen Commission extensively examined salmon farming in British Columbia. In fact, one of the report's key deadlines under recommendation 19 with regard to the Discovery Islands passed during our engagement period. On December 17th, 2020, Minister Jordan announced her intention to phase out existing salmon farms in the Discovery Islands by June 30, 2022. This announcement certainly affected the content of submissions during the engagement on the broader finfish transition plan.

The announcement also highlighted that any responsible transition strategy must position the sector for growth and job creation, with particular attention to rural and coastal economies. Farmed salmon aquaculture biomass has been plateauing over the past ten years and adopting more sustainable finfish aquaculture approaches and supporting diversification will help provide more growth and opportunities to this sector. Significant reductions in biomass in the Broughton Archipelago and the Discovery Islands gives us an opportunity to measure the economic impact of these decisions on local economies as well as the environmental impacts on local marine ecosystems. In my view, a significant impact study of these decisions should be thoroughly resourced to inform the broader strategy with regard to a responsible transition.

It is going to be essential for all levels of government and Indigenous representatives to work extremely closely and with urgency during the next stage of this transition. A large percentage of tenure decisions will need to be made by June 2022—an important milestone for this transition. The decisions made during this transition will have a significant impact on the livelihoods of British Columbians, and it will be important for us to work together to build a shared vision for a responsible path forward. Done correctly, I believe this can be part of a larger, multi-pronged approach to recover Pacific salmon stocks to traditional levels of abundance while growing a globally competitive and sustainable aquaculture industry in British Columbia.

Shared information gathering, leadership, and decision-making would also present an additional opportunity for the future management of aquaculture and wild salmon in British Columbia. Justice Cohen identified many stressors to wild salmon in his report beyond salmon farming which included: predation, infectious diseases, contaminants, and climate change, alongside further stressors in the freshwater environment including logging, agriculture, gravel removal, pulp and paper mills, mining, municipal wastewater, and other development-related impacts on fish habitat. This was in addition to algal blooms, sea lice, variations in marine productivity, and competition with other hatchery fish and non-salmon species. Many of these stressors cross multiple jurisdictions. A coordinated, multi-government approach with the goal of increasing the future abundance of wild salmon stocks and the future growth of a sustainable aquaculture industry would be an ideal alignment of interests for all parties involved. I think this approach aligns well with the vision set forward in Budget 2021 with regard to creating a Pacific Salmon Secretariat and a Restoration Centre of Expertise.

While there is still much work to be done, I am happy to present this interim report to lay the foundation for the transformation of the aquaculture sector in BC. Once again, thank you to all involved in this report, and I eagerly await the next steps in this historic process.

Terry Beech
MP – Burnaby North – Seymour
Parliamentary Secretary for the Department of Fisheries and Oceans

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Executive summary

In December 2019, the Prime Minister's mandate letter to Minister of Fisheries, Oceans and the Canadian Coast Guard Bernadette Jordan included a commitment to work with the Province of British Columbia and Indigenous communities to create a responsible plan to transition from open-net pen farming in coastal British Columbia (BC). From December 14, 2020, to April 13, 2021, Parliamentary Secretary Terry Beech, appointed by Minister Jordan, led an initial engagement process to gather input and perspectives on the development of a responsible plan for this transition.

This initial engagement process involved two days of pre-engagement sessions in December 2020 and seven days of virtual roundtable sessions with small groups and individuals. Participants included First Nations representatives, provincial and municipal governments, international experts and government personnel, fish health experts, veterinarians and pathologists, academics, environmental groups, investors, foreign aquaculture operators, local industry, and ancillary industry operators. Fin Donnelly, MLA for Coquitlam Burke Mountain and BC's Parliamentary Secretary for Fisheries and Aquaculture, attended as an observer representing the provincial government. Over 900 pages in written submissions were also gathered through an online survey and by email, both of which were open to the public. Over 5000 form emails linked to a David Suzuki Foundation campaign concerning the transition from open-net pen aquaculture were also received.

The engagement sessions addressed six key themes:

Definition and development of a responsible plan to transition

The following draft vision statement was presented for discussion: *To position BC as a global leader in innovative and sustainable aquaculture production, while protecting and rebuilding wild fish stocks as we transition from open-net pen salmon farming on the West Coast.*

Participants generally supported the vision of BC as a global leader in innovative and sustainable aquaculture production, but had a range of views on what it would entail. There was alignment in acknowledging the importance of protecting and rebuilding wild Pacific salmon stocks; however, when discussing how to transition from open-net pen salmon farming in BC, participants expressed a diverse range of views.

Participants shared ideas for the key components of a plan for a responsible transition from open-net pen salmon farming on the West Coast, and made suggestions for an appropriate process of engagement for providing input into the transition plan. Some of the key themes were openness and transparency, inclusivity, employing the best available science in decision-making, reflecting work already done on aquaculture, and aligning with the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

Advancing reconciliation[1]

Participants discussed the need to follow government-to-government protocols for engagement and decision-making and allow sufficient time for the process. A key concern was that many First Nations do not have the capacity or resources to fully participate in an engagement process. Views were shared on the significance of wild salmon for First Nations—culturally, economically, and as a food source. Participants discussed the role of traditional knowledge and local stewardship, as well as governance considerations. First Nations took a variety of positions on open-net pen salmon farms, with some communities opposed to having open-net pen farms in nearby waters and others actively involved in such operations. Alternate forms of aquaculture were also discussed.

Pacific salmon

Participants generally aligned in their recognition of the cultural and economic importance of wild Pacific salmon to BC communities, and the environmental, economic, and social impacts of the reduction in wild salmon populations. There was a significant diversity of views on the relationship between open-net pen salmon farming and wild Pacific salmon. While the many threats to wild Pacific salmon (including fishing, climate change, habitat loss, forestry and urbanization) were widely acknowledged, some people expressed the view that open-net pen farms are a source of additional harm to wild salmon, while others expressed the view that these farms do not pose significant risk.

Encouraging investment in BC aquaculture

Participants discussed BC's current and potential competitive advantage in the aquaculture sector and shared views on how to encourage investment and innovation in BC. A key theme was the importance of improving certainty for communities and industry regarding the federal policy and vision for aquaculture in BC. Participants shared views on how to optimize the regulatory environment, tailor government incentives and catalysts, and foster local infrastructure, knowledge, and research capacity.

Technology and innovation

Numerous forms of aquaculture were explored as potential alternatives to open-net pen farming. Information was shared on both land-based and marine-based systems, the latter including offshore aquaculture, semi-closed containment systems, and marine closed-containment systems. Hybrid systems, which use land and marine facilities at different stages of the life cycle, were also discussed. The discussions touched on a number of innovative technologies that can support these systems, as well as innovations in open-net pen technologies. There were a range of views on the environmental, economic, and logistical considerations for each type of aquaculture. Other ideas for innovation included circular economy models and whole-systems thinking, scaling aquaculture operations to sustainably meet the needs of communities, and growing other food like seaweed and shellfish.

[1] The UN Declaration on the Rights of Indigenous Peoples (UNDRIP) provided important context for conversations about transitioning from open-net pen salmon farming in a way that advances reconciliation with Indigenous Peoples. At the time of the engagement process, a federal bill had been introduced to bring Canadian law into alignment with UNDRIP, and the Province of British Columbia had passed legislation (which came into force in 2019) to ensure that BC laws are consistent with UNDRIP.

Governance considerations

Participants shared ideas regarding the legislative and regulatory environment for open-net pen farms currently in place, international models for regulating aquaculture, licencing and resource fees, and governance models. Area-based management was a governance option of interest to many.

Participants praised the model for putting the focus on people and ecosystems and enabling local decision-making based on local knowledge; but a key concern was the fact that local decisions could impact far-away areas, given the scope of salmon migratory runs.

Introduction

The Government of Canada recognizes the important role that aquaculture plays in Canada's coastal communities, for the economy, and for food security. The Government of Canada is committed to managing aquaculture responsibly, and to ensuring that Canada is a global leader in sustainable aquaculture. Aquaculture is generally recognized as one of the most efficient animal protein production methods in terms of greenhouse gas emissions and feed conversion rates. The Food and Agriculture Organization of the United Nations report, *The State of World Fisheries and Aquaculture 2020*, recognizes that aquaculture has a key role to play in feeding a growing world population with food that is nutritious and has a low carbon footprint. In BC, marine finfish aquaculture supports thousands of jobs in coastal communities and contributes significantly to the provincial economy. Sustainable aquaculture management is key to supporting a thriving aquaculture industry in BC.

The December 2019 mandate letter from the Prime Minister to Bernadette Jordan, Minister of Fisheries, Oceans and the Canadian Coast Guard, included a commitment to work with the Province of British Columbia and Indigenous communities to create a responsible plan to transition from open-net pen farming in coastal BC. On November 12, 2020, Minister Jordan announced that Parliamentary Secretary Terry Beech would be tasked with leading an initial engagement process on the development of a responsible plan to transition from open-net pens in coastal BC waters.

On December 14 and 16, 2020, Parliamentary Secretary Beech held two days of pre-engagement meetings, with Fin Donnelly, MLA for Coquitlam Burke Mountain and BC's Parliamentary Secretary for Fisheries and Aquaculture, attending as an observer. The purpose of these meetings was to prepare for the roundtable sessions and gather preliminary advice regarding how the engagement should occur and what the range of viewpoints could be.

They then held seven days of roundtable sessions between February 22 and April 13, 2021. In total, there were 114 accepted invitations to participate. Participants that attended included First Nations representatives, provincial and municipal governments, international experts and government personnel, fish health experts, veterinarians and pathologists, academics, environmental groups, investors, foreign aquaculture operators, local industry, and ancillary industry operators. Each day featured a series of 45-minute video meetings with different groups. In the first part of each meeting, people introduced themselves and stated their primary concerns. That was followed by a discussion. Meeting attendees and any other interested parties, including the general public, were invited to submit comments and additional information through an online web survey and an email inbox as well through an open process that ended on March 26, 2021. In response to the online survey, 476 submissions were received; 23 submissions unrelated to the questionnaire were received by email. Over 5000 form emails linked to a David Suzuki Foundation campaign concerning the transition from open-net pen aquaculture were also received.

This report is a non-exhaustive, as-was-heard summary of the opinions expressed and input gathered through the seven days of roundtable sessions and the pre-engagement meetings, supplemented by views shared through the online survey and email submissions.[2]

This was an initial engagement process. Phase 1 of a formal engagement process is planned to begin in the fall of 2021, and more information will be shared in the months leading up to that process. That formal engagement and other work toward the development of a transition plan will be informed by a detailed record of this initial engagement process, the extensive written submissions received, and the many suggestions for further research and resources to be consulted.

[2] For the production of this report, DFO contracted with a professional note-taker and a separate report writer to attend all video meetings and take detailed notes. The writer organized those detailed notes under the six key themes, expressing ideas in the words of participants as much as possible while summarizing the content. The report does not attempt to quantify or give weight to any of the views expressed. DFO staff reviewed the written submissions received to identify material that was not covered during the video sessions, and the writer incorporated additional points and detail into the final report. The report was prepared and finalized in consultation with DFO.

SECTION 1

Definition and development of a responsible plan to transition

COMMENTS ON CURRENT VISION STATEMENT FOR THE TRANSITION PLAN

Engagement participants commented on the following Fisheries and Oceans Canada (DFO) vision statement:

> **VISION**: To position British Columbia as a global leader in innovative and sustainable aquaculture production, while protecting and rebuilding wild fish stocks as we transition from open-net pen salmon farming on the West Coast.

Participants expressed a range of views on the vision as a whole and made comments on individual portions of the vision. Most expressed support for protecting and rebuilding wild fish stocks, but they did not agree on whether BC should make the transition from open-net pen salmon farming. The specific areas of disagreement on this point are discussed further under "Relationship between open-net pen salmon farming and wild Pacific salmon."

The following comments were made on the vision statement as a whole:

- The vision is "backwards" in the sense that the significance of wild Pacific salmon should appear at the very beginning, positioning it as the top priority.
- Rebuilding wild fish stocks should not be tied to the evolution of the aquaculture industry—it should be a separate initiative.
- Without sacrificing the health of wild Pacific salmon, the next priority in the vision should be to build strong economic opportunities for communities.
- The vision implies that there is a connection between rebuilding wild fish stocks and transitioning from open-net pen aquaculture. Some participants agreed that there is a connection, while some did not agree.
- BC should aim to be a global leader in sustainable wild fish stock resource management, rather than in aquaculture production of foreign fish species.
- While the vision statement outlines a necessary change, it is a huge endeavour and there will be many challenges—industry cannot do this all by itself.

- The vision should be to protect wild salmon through more innovative and sustainable aquaculture practices.
- The vision should also include language stating that First Nations have authority over their water and land.

Regarding the phrase, "...as we transition from open-net pen salmon farming on the West Coast," the following comments were made:

- The vision should focus on what BC is moving toward in terms of outcomes and standards, rather than what it is "transitioning from." It should not dictate which technology and methods are to be used in achieving the outcomes and standards.
- This phrasing is problematic because it does not say what the transition will lead to, and industry needs to know where the sector is going.
- It should be clear that "transition" means "change" and stated clearly that the change will be to land-based aquaculture.

There were requests for greater clarity on several aspects of the vision statement and the December 2019 mandate letter for the Minister of Fisheries, Oceans and the Canadian Coast Guard:

- If the direction taken is to transition from open-net pen farming, the industry needs clarity and specificity on which environmental impacts and risks need to be addressed, to help in planning which alternative technologies to adopt.
- It's not clear whether "wild fish stocks" is meant to refer solely to salmon, or includes all wild fish.
- More information is needed on how this transition plan relates to other federal initiatives, and how plans for the Pacific region align with the vision in other regions of Canada.
- Referring to the mandate letter, some called for a clear definition of a "responsible transition" and a better understanding of what "transition" really means, and for greater clarity on the commitment in the mandate letter and the intended outcome of this transition process.
- Is open-net pen farming of Pacific salmon also a concern that will be addressed, in addition to the farming of Atlantic salmon?
- Is it assumed that the transition will be to some other form of salmon farming? Other, more regenerative forms of aquaculture could include growing things like shellfish or seaweed, which could help to improve fish habitat.
- How would the aquaculture industry prove that it is "sustainable"? It should be rebuilding the wild fish stocks.

Several suggestions were made for improving the vision statement:

- Define "responsible" as set out in the mandate letter.
- State that the transition should be sustainable, and define what that means.
- Focus on sustainable activity and protection of the environment.
- Focus on the end state that changes are meant to achieve, rather than on specific technological solutions.
- Include a "human" aspect to the vision, such as having healthy communities.
- Include words on rights for title holders.

DEFINITION AND KEY COMPONENTS OF A RESPONSIBLE PLAN TO TRANSITION

Many participants agreed that there needs to be a plan if BC is going to transition from open-net pen salmon farming, although there was not agreement on whether that transition should take place or what it should look like.

Participants identified multiple components of a responsible transition plan:

- Transparency and open communication
- Protection of the First Nations rights-holder status and compliance with UNDRIP
- Consideration of the priorities of the Fisheries Act, which were said to be confirmed by the Supreme Court: the conservation and protection of fish, the protection of Indigenous fisheries, and the protection of commercial fisheries and aquaculture
- Inclusion of current transition activities such as the Broughton agreement and the Discovery Islands changes
- Science-based decision-making guided by the precautionary approach and referencing international models
- Informed by a comprehensive understanding of the salmon farming industry and how all impacted parties are affected
- Measurable goals and targets to monitor short- and long-term success, for both aquaculture production and wild salmon returns
- Clear objectives, timeline, and accountabilities, with interim steps and annual public reporting
- Fostering of innovation, including exploration of emerging technologies (such as containment technologies) and their feasibility and suitability to the region
- A plan for the fish currently in open-net pen farms, and for the smolts in hatcheries
    - A plan to transition and possibly retrain workers, to prevent net job loss
    - Remediation of the areas used by fish farms
    - Increased licence fees for open-net pen fish farms prior to the transition
    - Prioritization of the preservation of wild salmon—rebuilding and enhancement of habitat
    - Monitoring of environmental factors, marine health and fish populations, with data shared in a timely way on a public website to ensure transparency and accountability
    - A means to resolve the continuous and divisive debating that has reduced public understanding and trust (e.g. by moving to area-based management)

Some participants stipulated that the only responsible transition would be to land-based aquaculture. Others disagreed and had various suggestions for marine-based options that would address any concerns related to open-net pen farming (as discussed further under "Technology and innovation").

TIMELINE FOR THE TRANSITION PLAN

Regarding the 2025 timeline for a plan to transition from open-net pen salmon farming, some participants said they felt strongly that the process is happening too fast, while others said it must happen as soon as possible. One participant asked whether 2025 was the date targeted for having a plan in place or the date for having open-net pens completely out of the water.

Some participants said that three to five years was an appropriate timeline for transitioning out of open-net pen farming.

Those who felt the transition is happening too fast said that a common vision should be developed first, before steps are taken to plan and make the transition. It was noted that the industry would need time to transition as they had to plan for a biological cycle of four to seven years. Shutting down in the midst of that cycle is very disruptive, it was suggested, and some companies may have to cull fish. The timeline for switching from open-net pen operations by 2025 may be too short for some First Nations and remote communities that are currently running those operations, if they do not have sufficient infrastructure in place (e.g. power or water supplies to operate land-based facilities).

Those who felt the transition must happen as soon as possible emphasized that in their view the issue is urgent and it is important to make the transition by 2025. Removing open-net pens from the water as soon as possible would address their harm to wild salmon stocks, they said. Some participants added that the transition from open-net pen salmon farms has been recommended for about 20 years, with several processes recommending that open-net pen farms be removed from the water, starting with the 2001 Legate Inquiry and more recently discussed in the report of the Cohen Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River. ("Cohen Commission report"). One person suggested that the government should simply pass a law to get the open-net pen farms out of the water.

Several suggestions were made for compromising on the timeline:

- If there is a strong plan with measurable goals and targets that are monitored, having a transition that is a bit late is okay, as long as it is occurring.
- The transition plan could focus on removing sites in areas of higher harm first (such as those closest to migratory pathways).
- Short-term changes in procedures could address the most urgent issues, while allowing time for a more fulsome process of discussion.

PROCESS OF ENGAGEMENT FOR PROVIDING INPUT INTO A TRANSITION PLAN

Open, transparent, and inclusive

Participants called for an open, transparent, inclusive process of engagement where everyone affected by the decisions feels involved and can contribute. Some said that they had expected a formal consultation process with a secretariat, website, and email. It was also suggested that the process should lead to a shared vision, rather than being built around a pre-established vision. Suggestions for improving openness and transparency included making meeting summaries public, providing progress reports on the transition plan, providing sufficient time for meaningful engagement, ensuring that decisions are guided by science, raising local awareness and prioritizing local voices, and holding consultations in the communities directly affected. Some participants expressed the view that the situation is past the point of an open and transparent process, given the Discovery Islands announcement.

Suggestions were made for who to include in the engagement process:[3]

- Local First Nations
- First Nations rights and title holders by region
- People with Indigenous traditional knowledge and community knowledge
- People who live and work in the remote communities most affected
- Companies in the aquaculture industry
- Workers in the aquaculture industry with on-the-ground knowledge
- Businesses that provide services ancillary to the aquaculture industry
- Municipal governments
- The Province of BC and all orders of government
- Wildlife tourism sectors
- Small land-based farm operators
- Researchers and experts
- All relevant interest and stakeholder groups
- Everyone who wants a voice in this process

[3] Participants were not explicitly asked to provide a full list of list groups that they would like to see included in the engagement process, but were asked for suggestions to ensure that the process would be open and transparent.

Several participants said that the consultation should be made public (factoring in privacy considerations) and that public input should be sought as well. This could include a website to ensure transparency and accountability.

Models and suggestions for an appropriate process

Participants shared a few examples of other processes that could serve as models:

- The Broughton process
- The Killer Whale symposiums
- The species at risk model
- Metro Vancouver's Liquid Waste Management plan

Several participants advocated for a participatory process, which they said would give all stakeholders, as well as the general public, an opportunity to review the information and learn about the shades of grey in assessing the pros and cons of aquaculture.

One suggestion was an expanded version of the Broughton process, either breaking the province into regions or designing a tiered consultation with one large table and several focus groups that feed into it. Many said that the Broughton process was a good model for an overarching provincial approach and an example of shared decision-making, and that it was a fair process. Another perspective was that the Broughton process was limited in its application, and was possible because there were no pre-existing protocol agreements in the Broughton area. It was noted that the open-net pen aquaculture discussion would be more complicated as it involves different jurisdictions, potential technological changes, a labour disruption, and possible investment in innovation by companies.

Others suggested a problem-solving approach where companies, First Nations, and others would be invited to come together and identify a practical path forward that would meet pre-defined criteria for success (such as regulatory requirements and objectives).

In general, participants recommended that the process should start with the development of a common vision, and then work backwards to develop the regulations and standards needed to support that vision. The process should begin with a clear articulation of the foundations of decision-making.

Who should lead the process

Several participants suggested that there was some distrust of DFO as the organizer of an engagement process for providing input into a transition plan. To increase transparency and trust, a number of people suggested bringing in a neutral, non-governmental third party to lead the formal engagement process. While many saw a supporting role for DFO in the process, one suggestion was to limit the participation of the Aquaculture Management Branch, to avoid any potential or perceived conflict of interest.

Alignment of the engagement process with previous work and role of governments

Clarity was sought on how this process would build on past work related to new aquaculture technology, as well as on the role of the Province of BC in this process. A number of participants said that the role of governments should be to ensure that the process is fair and open, with some emphasizing that local governments and First Nations should have primary roles.

Alignment with UNDRIP and principles of reconciliation

It was noted that the process must be consistent with UNDRIP, incorporate and recognize First Nations titles and concerns, and make decisions based on principles of reconciliation. Specific suggestions on how this could be ensured are summarized in the "Advancing reconciliation" section below.

INFORMATION AND RESEARCH FOR DEVELOPING A RESPONSIBLE TRANSITION PLAN

Employing the best available science in decision-making

There was considerable discussion of the science around both open-net pen aquaculture and wild Pacific salmon, and how to incorporate the best of that science into decision-making.

While science can provide a basis for making sound decisions, this is complicated by the fact that aquaculture science has areas of grey, said several participants. One person acknowledged that it is difficult to parse the science when different experts have different views, and suggested that DFO scientists who oversee fish health in the region and gather data on the ground could contribute useful knowledge.

Participants suggested that when incorporating science into the decision-making process, decision-makers should consider the full range of DFO and independent peer-reviewed science, as recommended by the Cohen Commission report. Some cautioned against placing trust in scientific advice from groups with a vested interest, while others commented that biases should be accepted as unavoidable and declared upfront.

Several people urged that if there was doubt or confusion regarding the scientific basis for the plan to transition from open-net pen farming, then it would be worthwhile to take the time for a discussion of the science. Some people said that it was important to clarify what the questions and issues are—what the transition plan is meant to address.

Participants made a number of recommendations for incorporating science into the decision-making process:

- Trust existing scientific bodies.
- Listen to impartial scientists and peer-reviewed science.
- Do literature reviews and refer to existing reports on aquaculture.
- Provide sufficient funding to investigate any open questions.
- Fund an independent advisory committee to review evidence, answer questions, and provide advice.
- Gather information on international best practices, and deepen collaboration with leading salmon-producing nations.
- Consult local people with on-the-ground experience, and incorporate traditional ecological knowledge.

One point made was that while decisions should be informed by a scientific risk assessment, they are ultimately made based on a multiplicity of factors. In addition to environmental and economic considerations, decision-makers may also consider community and Indigenous knowledge and socioeconomic considerations. One intangible factor mentioned was social licence, with some people commenting that there is strong support for open-net pen farming in parts of BC, and others saying that on this issue, multiple factions have aligned to oppose open-net pens.

Additional information and research

While some participants stated that sufficient research exists to proceed with a plan regarding open-net pen salmon farming, others made suggestions for further research that would be useful in developing a responsible transition plan. A number of sources of information and suggestions for further research were also submitted via the web and email during the engagement period. See the appendix at the end of this report for more information.

ECONOMIC CONSIDERATIONS FOR A PLAN TO TRANSITION FROM OPEN-NET PEN AQUACULTURE

Many participants stressed the economic importance of the salmon farming sector for communities and First Nations, sharing details about the many businesses and local jobs in the sector, both directly in fish farming and through the chain of suppliers and services. Another consideration was that through this employment, money then flows to the local community, other businesses in the local community, and not-for-profit organizations.

Planning and government support for the sector during the open-net pen transition plan

Several participants said that the broader plan to transition from open-net pen salmon farming by 2025 would need to be done carefully; otherwise, businesses would be hurt and the seafood industry in Canada would be damaged. While Canada is a net exporter of salmon to other markets, it also imports salmon, and a concern raised was that if production stops, product will come in from other countries to fill the gap, with people in BC losing their livelihoods. It was also noted that the trained labour, expertise, suppliers, and services that support the industry are a key part of BC's competitive advantage and would be negatively affected by a transition that is not well-planned.

Participants made several suggestions for actions the government could take during the transition from open-net pen aquaculture to help local communities adapt. The following ideas were shared by one or more participants:

- Make the transition slowly and incrementally.
- Focus on another method of growing fish that would make the same economic and social contribution to the rural fabric and economy.
- Support infrastructure development in coastal communities, including power, water and sewage systems, road access, green energy, product storage, and infrastructure that would enable the development and improvement of alternative aquaculture technologies.
- Allow aquaculture farms to engage in a short-term program of ocean ranching to provide fish to the coastal industry for harvest while natural habitats are being rebuilt.
- Speed up DFO research on mark-selective fishery management and using mass marking to learn more about stocks. This would provide information on where different species spend time and how much they travel. Through mark-selective fisheries, species that do not travel much could provide benefit to communities once they reach minimum legal size.

VIEWS ON THE DISCOVERY ISLANDS DECISION

Participants provided feedback on the federal government's December 17, 2020, announcement that salmon farming licences would be phased out in the Discovery Islands by June 30, 2022. This announcement was separate from the federal mandate to develop a responsible plan to transition from open-net pen salmon farming in coastal BC waters by 2025.

Some participants stressed that it was urgent to close down open-net pen salmon farming as soon as possible to protect wild salmon stock and praised the Discovery Islands decision, while others were strongly opposed—particularly to the short timeline for the closing of the Discovery Islands farms.

Environmental considerations

Some participants in support of the Discovery Islands decision shared their view that it would be environmentally beneficial, making the following statements:

- Given the many threats wild salmon are facing in their own environment despite massive declines in fishing activities, salmon aquaculture has to take its share of the dislocation, and closing down the Discovery Islands open-net pen farms is the right decision.
- The Cohen Commission report recommended taking action on this by 2020.
- The Discovery Islands decision should be applauded because wild salmon and Atlantic farmed salmon have difficulty coexisting, and from this perspective open-net pen farms are not advisable in the Discovery Islands or Broughton Archipelago areas.
- The Discovery Islands decision was a difficult but important decision that is supported by science.
- Mouth rot is much higher in areas around farms than elsewhere and is being passed on to wild salmon in the Discovery Islands. This is just one of 39 pathogens identified.

Impacts on employment and local economies

There was considerable discussion of the economic impacts of this announcement on communities.

Many participants said that local businesses in aquaculture are now laying off employees, some of whom had been trained and hired with government financial support. In general, the view was that local businesses connected to open-net pen farming now had to stop investing, lighten their workforce, and rethink how to use current assets. Some predicted collateral damage to the supply chain by June 2022, with the potential for larger companies to move their investments elsewhere if policy decisions are not supportive of the industry.

Participants noted that many of the small BC communities impacted by the decision have already been affected by changes in commercial fisheries, logging, and mining. They warned about the socioeconomic impacts of this latest change, with one person raising concerns about issues like outmigration and homelessness. Some asked what the federal government would be doing to support these communities.

One participant local to the area offered a different perspective on the impact of the Discovery Islands decision, stating that only a few workers on the area's fish farms are locals, and suggesting that these individuals could easily be employed elsewhere. They mentioned opportunities in other aquaculture enterprises, such as scallop or kelp farms, and specific job openings listed in a number of other sectors. They also called for government investment in local businesses and conservation efforts that could provide further employment.

Another participant observed that every aspect of the economy is being impacted by environmentally mandated changes, and said that just as the commercial fishing sector has been impacted by mandates to protect wild salmon, the aquaculture sector will also inevitably be affected and will have to adapt.

Impacts on industry and innovation

Several participants said that larger companies were freezing investment in BC aquaculture and may consider refocusing on other jurisdictions due to a lack of certainty and a lack of clarity regarding the regulatory and policy vision for BC aquaculture.

If a large percentage of production can be shut down overnight, they argued, then companies cannot feel comfortable investing in BC.

One point made was that some companies had planned to use the income from existing open-net pen farms to finance experiments with closed-containment or land-based operations, and they were now unable to move forward with these plans.

First Nations views on the decision

First Nations views on the Discovery Islands announcement varied: one stated that they had already been negotiating to have industry vacate the area by 2022, so the Minister's announcement was aligned with those plans. Others said that they were not satisfied with the announcement because it did not involve consultation and did not allow for a transition period. One participant expressed frustration that First Nations were being blamed for the announcement, saying they had wanted to do the right thing in a planned way, and not to affect people's work and livelihoods.

Comments on the decision-making process

Participants made the following comments on the process around the Discovery Islands announcement and next steps:

- Local aquaculture interests and larger companies feel blindsided and disenfranchised.
- The socioeconomic impact does not seem to have been taken into account, and mitigating strategies for locals are not sufficient.
- Relations with the federal government have been negatively affected.
- Companies thought that by addressing the Cohen Commission recommendations they would be allowed to continue operating, at least until 2025.
- There is a contradiction between providing federal funding to improve open-net pen systems, which occurred recently, and then eliminating those operations.
- There is no clear indication of what the transition might look like. The effects in the area should be monitored after removal of open-net pen farms. Economically, communities need support to make the transition.
- Some participants said that the decision was rushed and done without consultation and that people are feeling disenfranchised, while others said the need for this change had been discussed over many years and it had happened too slowly.

SECTION 2

Advancing reconciliation

UNDRIP AND GOVERNMENT-TO-GOVERNMENT RELATIONS

The UN Declaration on the Rights of Indigenous Peoples (UNDRIP) provided important context for the discussions. At the time of the engagement process, a federal bill had been introduced to bring Canadian law into alignment with UNDRIP, and the Province of British Columbia had passed legislation (which came into force in 2019) to ensure that BC laws are consistent with UNDRIP.

> **The BC act stipulates:** *"In consultation and cooperation with the Indigenous peoples in BC, the government must take all measures necessary to ensure the laws of BC are consistent with the Declaration."*

Decision-making regarding aquaculture and fisheries

Several issues were raised regarding an ongoing lack of proper engagement with First Nations on fisheries and aquaculture, and the general principles that should be observed instead. Participants shared some experiences with DFO that illustrated these concerns:

- Some said they had received form letters either informing them on short notice of an aquaculture development, or responding to First Nations concerns communicated to DFO about an aquaculture issue.
- One nation discussed seeing industry get better access to the Minister and having more resources to spend time in Ottawa lobbying.
- Another nation said they had been trying to work with DFO to conduct their own habitat studies and set up hatcheries within territories.
- "We have a strained relationship with DFO," said another participant, explaining that they had taken DFO to court over a decision that had gone against an agreement they had in place.
- "We the chiefs gave the authority to DFO to manage the resources and we've come to the state where we're at the last buffalo, only instead it's the last wild salmon and the last herring," said one participant.

Several participants said that in their view DFO had been working in the interest of industry rather than salmon for decades and cited the Cohen Commission report as stating that this duality needs to be eliminated. Indigenous law must be incorporated into aquaculture management, many said, and it was noted that some nations are considering doing their own monitoring and enforcement of farms in their territory.

Engagement on the mandate to create a responsible plan to transition from open-net pen salmon farming

Participants said that the federal government should clarify how UNDRIP will be implemented in this process, and should employ a nation-to-nation, government-to-government model of shared decision-making. A key point was that there are different protocols for different First Nations. While organizations can play a role as convenors or in identifying common areas of concern and joint interests, they do not speak for all of the nations. One nation discussed being a "modern treaty nation," noting that this is not the case for all nations. To respect treaties, the federal government must be familiar with what it has agreed to in each treaty and proceed accordingly, they said.

Engagement process

Participants made several specific recommendations on an engagement process that would appropriately involve First Nations:

- Respect the sovereignty of First Nations, acknowledge their territories, and do not bundle them in with industry or communities. Provide opportunities for First Nations leadership and relationship-building with federal and provincial governments. Use a tri-partite government-to-government process.
- Make the role of the BC government in this process clear, and clarify how the BC government's commitment to consent-based tenure licencing by 2022 will affect the development of the transition plan.
- Involve First Nations in designing the process. Support an Indigenous leader to co-lead on this process, and have a process where the First Nations can self-organize.
- Ensure that people have communication materials to bring back to their communities.
- Provide sufficient time. The cultural way of determining the best solution is that everyone has a voice and is heard. This requires more than a few minutes of engagement.
- Recognize that the one-on-one format works better for some than being combined with a huge group of nations with varying perspectives and having to share floor time.
- "Consultation" is not an appropriate term—rather, this should be a government-to-government consent process.
- Consider the incorporation of Indigenous knowledge within the process.
- Explore the Broughton process and its implementation of UNDRIP as an example of shared, consent-based decision-making. In that process, the federal government met with hereditary and elected political leaders.

Many participants called for an independent third party to manage the engagement process, rather than DFO, citing a lack of transparency and perceived conflicts of interest, as DFO also oversees aquaculture. It was also noted that this third party could be made up of (or include) First Nations.

First Nations capacity to engage

Another issue was First Nations capacity and resources to fully participate in an engagement process. The federal government was urged to build resourcing and capacity support into the process to ensure strong participation from First Nations communities. Some participants shared examples of this capacity issue, such as not having the time or resources to learn about the issue on which they were being consulted, having too heavy a workload to focus on an external matter (as well as local crises to deal with), and now, having to deal with Covid-19.

Ensuring inclusiveness

The following comments were made on who should be included in engagement processes:

- Involve each of the nations.
- Include hereditary chiefs.
- Engage the Union of BC Indian Chiefs and the BC Assembly of First Nations in this process.
- Have an "opt-in" approach for First Nations engagement, with a specific structure and process.
- Fully engage the rights-holders and engage with title-holders that have working relationships with industry.
- Include experts on the issue and on the legalities of First Nations consent.

SIGNIFICANCE OF WILD SALMON FOR FIRST NATIONS

Participants discussed the significance of wild salmon to First Nations—culturally, as a food source, and economically—and the impact of declining wild salmon populations.

Cultural significance

Some First Nations participants said that salmon "has been part of us since time immemorial; that is why we have a chapter in our treaty on fish." Wild salmon are integral to First Nations traditions, their traditional diet, and a vital basis of their livelihoods and communities. Salmon fishing kept the youth occupied with healthy activity. If there is no salmon to catch, they added, traditional knowledge will be lost.

Food security and traditional diet

Participants noted that wild salmon are integral to the traditional diet of BC First Nations. Where they have an abundance of wild salmon, communities are able to achieve their food requirement. Where this is not the case, people must rely on grocery stores as a food source. One First Nation described wild sockeye as "our medicine, our food" and said in the past three years they had not had any. BC First Nations rely on salmon and other marine resources as food sources, they said.

Economic significance

Many First Nations participants discussed the historic importance of the commercial salmon fishing industry, with some saying people still rely on commercial fishing for income, but catching salmon is "always touch and go" and it is difficult to compete with other fishers. The economic impact of losing wild salmon populations has been huge, said First Nations participants—and many other problems followed that loss. Fishing that was plentiful in the coastal territories has been reduced to nothing. One nation whose people had lived off the sockeye run "since forever" now counts every fish that returns and has seen a consistent decline in salmon numbers over the years.

TRADITIONAL KNOWLEDGE AND LOCAL STEWARDSHIP

First Nations traditional knowledge

Several First Nations discussed their efforts toward protecting and rebuilding wild Pacific salmon stocks and habitat, and the role of traditional knowledge in understanding the ecosystems of their territories.

Some First Nations commented on the changes they had observed in the ecosystems that support wild salmon. They spoke of elders who remember the salmon populations that used to exist in the area, and who could attest to changes in the ecosystem such as invasions of jellyfish and squid, blooms of different kinds of plankton, drought, flash floods, and rivers that are no longer being cooled by glaciers. One view was that, in light of all these changes, wild salmon would not recover to its former abundance, and it was suggested that they were now "fighting over the last fish."

The role of elders as keepers of traditional knowledge was discussed in relation to local governance efforts, and it was suggested that elders have a lot to offer toward finding solutions to the many pressures on wild salmon, including changes to forests and watersheds.

Local stewardship and enhancement

It was noted that a one-size-fits-all set of regulations for aquaculture will not work for a number of reasons, including variations in local geography. For example, the steepness of a river bank impacts the optimal buffer zone for salmon spawning areas, so a local buffer zone may need to be adjusted.

Local monitoring and conservation were seen as the main tools for properly managing ecosystems, and some examples were given of First Nations efforts currently underway to protect and rebuild wild salmon stocks:

- Fertilizing a lake to bring back a sockeye run that is currently extinct: The challenge is that when the fry hit the ocean, if there is a sea lice issue, it counteracts all the careful work to start them in the lake. Juveniles are a critical part of any salmon run and are subject to the highest mortality, facing challenges at every stage.

- Setting up open-net pens to hold chinook salmon fry that emerge from the river until they mature to a point where they are less vulnerable to predators.
- Doing research on estuaries and different salmon species.
- Raising funds for enhancement efforts through a conservation fee for tourist participation in local bear tours.

Participants made the following suggestions for supporting and increasing First Nations stewardship and enhancement efforts:

- Co-management of the resources in First Nations territory. When nations are able to get accurate information, they can work with others to mitigate any issues.
- A guardian program with cabins for the guardians.
- Capacity building to enable data collection, oversight (including the guardians) and traditional knowledge.
- Monitoring species with a wider lens, to better predict and address pressures on salmon (e.g. monitoring herring).
- Funding to restock rivers with sockeye (although this will be challenging, considering the impacts of forestry).
- An application process for activities that impact First Nations lands and water, requiring the applicant to demonstrate how they will mitigate environmental impacts.
- Core funding for First Nations to hire full-time fisheries managers or coordinators.

It was noted that increased enhancement efforts could create employment for many people.

FIRST NATIONS POSITIONS ON OPEN-NET PEN SALMON FARMING

First Nations positions on open-net pen salmon farming were wide-ranging, with some saying the farms should be removed from the water as soon as possible and others saying that they intended to continue open-net pen farming on their territory. Some First Nations said that while they did not support open-net pen salmon farming in their territory, they recognized the benefits it had brought to other First Nations and wanted to ensure that a plan to transition to something else would not impact those communities negatively.

First Nations participants who **did** want to see a transition from open-net pen farms expressed the following views:

- If fish farms are going to be allowed to stay, we have to be at the table. Those fish travel. We have to think about our neighbours and the animals that depend on wild salmon.
- We do not support any further water-based salmon farming. We support the transition to land-based salmon farms by 2025.
- Our common objective is the protection of wild stocks. We need joint operations by Canada, BC and First Nations to do this. We need our wild salmon stocks for jobs, food and economic fishing rights.
- Until aquaculture was introduced to our waters, we had no worries about sea lice.
- The best solution is land-based aquaculture, and there’s proven technology to do this.
- We can no longer have profitability at any cost. We need to save the wild salmon. There is other work to do but we can take this step quickly and watch for immediate relief.
- Having fish farms in any area on the coast is an infringement of Indigenous rights and title to the salmon fishery. All Indigenous people along the Fraser River need to have a say in this decision.

First Nations participants who **did not** want to see a transition from open-net pen farms, or who were open to changes that would allow open-net pen farms to remain, expressed the following views:

- We are not opposed to open-net pens in the ocean, or to closed containment, but they should not be in the inlet where all the fish grow.
- We're only asking that it be managed better. Clams, herring and prawns are impacted. We respect those who have agreements, and they respect us.
- It is up to each nation to decide what is right for them, as long as it doesn't impact the fish in our waters.
- A cookie-cutter approach won't work because what's sustainable in one area might not be somewhere else.

FIRST NATIONS INVOLVEMENT WITH SALMON AQUACULTURE

First Nations partnerships with industry

A number of First Nations participants discussed the economic importance of open-net pen salmon farming to their communities, as well as the history of how they became involved in the sector. They shared a range of experiences with the aquaculture industry.

Several nations said that they had resisted entering into impact-benefit agreements with companies to have open-net pen aquaculture on their territory, but had ultimately made the agreements because they saw the development as inevitable and felt it was better to receive some benefit. They mentioned several factors that led to this decision:

- A past BC government call-out for aquaculture made the open-net pen presence in the area inevitable.
- Nations lacked funding or capacity to pursue litigation to keep open-net pen farms out of their territory, so they chose to sign on instead.
- Nations were under economic duress, partly due to the loss of the commercial fishing and processing sectors.
- Agreements in overlapping territories mean that the salmon farming was going forward anyway, so nations that would not have supported it signed on in order to have some benefit.
- One nation that was salmon farming on its own since the 1980s found that it could not compete when the multinationals arrived, so entered into a partnership.

It was also suggested that members of some nations may not always uniformly support leadership decisions to sign agreements with aquaculture companies.

Discussing their impact-benefit agreements with aquaculture companies, some First Nations participants had concerns and negative experiences to report:

- One concern expressed was that nations and employees are not allowed to share information about their experiences, and in some cases had signed non-disclosure agreements that prevented them from discussing issues of concern. One of the problems discussed around this practice was that when one nation is having problems, they cannot discuss those problems with another nation before that other nation signs its own agreement.
- Some said they were not able to monitor the fish farms in their area and were not informed when problems occurred.
- Another issue discussed was that the financial benefits can be limited—for example, the cost of training community members may be subtracted from payments made to the nation, and more benefits may flow to the location of the head office or out of the country than to the First Nation.
- One nation reported that many of the jobs originally gained through an agreement with industry had been automated, and now only two people from the nation were employed with the company.

Other nations said that their relationships with aquaculture companies had been positive and beneficial—in some cases providing the funds for wild salmon restoration efforts. Several described their positive experiences in depth:

- One nation said that their industry partnership in salmon farming provides 50 percent of their jobs, and the farming is all done on the nation's terms. They have operated at the same scale for 15–20 years and they deny industry requests to expand the operation.
- Another nation described their industry partnership as a positive relationship that involves a strong protocol agreement that addresses all environmental concerns. At the company, 30–40 percent of the staff are members of the First Nation, and up to half of the community is employed in fish farming. They said that this was a better option than commercial fishing for wild stock, which in their view could wipe out wild salmon populations.
- Another nation described a "cutting-edge" monitoring agreement with its industry partner, which is one of the biggest employers in the region and a key source of jobs for the nation. The nation has two independent biologists doing research and monitoring.

Among First Nations involved in open-net pen salmon farming, responses to a potential transition from this method varied, from a commitment to defending the right to continue open-net pen aquaculture on First Nations territory, to a willingness to work with an industry partner who was open to moving to a land-based operation.

Economic impacts of closing open-net pen salmon farms

First Nations involved in open-net pen salmon farming echoed many of the concerns expressed by other communities regarding a transition from this form of aquaculture, making the following comments:

- The cost of transitioning from open-net pens would be millions of dollars over the next five years.
- Thousands of jobs would be lost. Many jobs are being created in open-net pen salmon farming while layoffs are occurring in other industries in the community.
- Other First Nations businesses that support open-net pen salmon farming would not survive.
- Some First Nations would be left in debt after significant capital investments in vessels and infrastructure.
- Industry partners that have good working relationships with First Nations may leave the communities, resulting in "a devastating crisis."

Economic options for First Nations communities that rely on aquaculture

Among those First Nations who wanted or were willing to transition from open-net pen farming, views varied on which alternatives would be acceptable. Some said that the only way to protect wild stock was to fully transition to land-based aquaculture. Others said they were open to exploring various technologies and would decide for themselves which options would address their concerns.

Some nations said they are not ruling anything out and are open to learning about the options, but generally stipulated that any form of aquaculture adopted would have to pass environmental and business assessments.

Some industry participants discussed challenges with regard to developing alternative aquaculture technologies with First Nations partners:

- Capacity issues: Some nations are overwhelmed with incoming requests from resource sectors in BC and this presents a challenge to building relationships with industry partners.
- Lack of reliable utility services (water, power, etc.)

- Isolation/remoteness (plane and boat access only) presenting logistical challenges
- Overlapping territories

Land-based aquaculture

Some First Nations suggested that land-based aquaculture was an economic development opportunity for First Nations that would allow them to retain aquaculture jobs while transitioning from net pen aquaculture. It was suggested that government incentives could help to develop land-based aquaculture. One First Nation suggested that in their area the rivers could provide abundant hydro power, and land use would be more affordable than in the Vancouver area. It was also noted that for those nations in the process of treaty negotiations, interim measures are available to set aside lands for this type of activity.

One point made was that while larger companies may not see land-based aquaculture as profitable enough for shareholders, First Nations could run successful aquaculture businesses on their own, in a different corporate model that would simply focus on building sustainable businesses.

An opposing view was that in some communities land-based aquaculture would be too expensive and impractical.

Alternatives to salmon aquaculture

Several First Nations expressed interest in kelp and seaweed farming, shellfish aquaculture, and mariculture as emerging opportunities that could also be environmentally beneficial alongside watershed restoration efforts. It was noted that kelp farms could provide habitat and shelter for fry as they emerge from the river on their way out to sea, and be a source of income or blue credits.

One First Nation currently involved in open-net pen salmon farming said that switching to other aquaculture species would require significant investment and would not be an option for them.

In a brief discussion of ocean ranching, some participants expressed interest but it was suggested that pilot programs had not led to this sector taking off.

Excess-to-surplus fisheries were also mentioned as one option for helping salmon and also providing revenue. If enhancement efforts are successful, a nation could take some of that excess.

CONSIDERATIONS FOR A TRANSITION PLAN THAT ADVANCES RECONCILIATION

Various First Nations listed some principles and ideas for the transition plan that they said would be important to honour in their territories:

- When the pens are moved, do environmental assessments to learn what has been happening beneath them.
- Allocate funds toward rehabilitation and enhancement programs and implement them.
- Oversee the decommissioning of the sites to ensure that there is no net loss of habitat.
- Turn tenure over to First Nations—transfer licences to them.
- Strive for local management, local decisions and local benefits.
- Support the rights and title of First Nations to the wild salmon fishery.
- Ensure First Nations collaboration in the economic opportunity of aquaculture development and the development of the Blue Economy in BC.
- Protect First Nations culture.

SECTION 3

Pacific salmon

RELATIONSHIP BETWEEN OPEN-NET PEN SALMON FARMING AND WILD PACIFIC SALMON

Participants agreed that conserving and protecting wild Pacific salmon is a top priority. There were a variety of views on the relationship between this goal and the mandate to create a responsible plan to transition from open-net pen salmon farming in BC. Some participants expressed the view that this transition is an urgent step required to protect wild Pacific salmon, stating that Pacific salmon are affected by many stressors and the precautionary principle should apply in this situation. Others said open-net pen farms do not present a significant risk to wild salmon and pointed out the impacts of numerous other stressors on wild salmon, such as overfishing, illegal and unregulated fishing on the high seas, commercial and recreational fishing, climate change, ocean conditions, habitat loss, new pollutants, forestry and urbanization, as well as ocean ranching in Alaska and Russia.

Some said that the primary concern for wild salmon is not the existence of open-net pen fish farms, but rather certain practices. For example, some salmon farms are located on migratory routes of salmon smolts, and keep their lights on at night, which some asserted attracts young salmon. Another issue is that juvenile salmon tend to stay closer to shallow waters while the adults move to deeper water, thus the contact between juveniles and farmed fish is higher. However, the view was also expressed that sufficient work has not been done to calculate the real damage to juveniles from fish farms, including sea lice impacts.

Some participants expressed the view that open-net pen farms can have a harmful impact on wild salmon, but said that there is room for compromise on how the issue is addressed. One suggestion was that if open-net pen farms cannot all be removed in the short term, the highest-priority areas would be the ones near migratory paths. However, another view was that there is nowhere on the BC coast to locate farms away from migratory routes, and closing only some sites would simply mean choosing some stocks to put at risk over others.

One concern raised was the belief that DFO has "no teeth" to enforce proper sea lice management. Stronger regulatory enforcement, it was suggested, could allow open-net pen farming to continue.

Those who said that open-net pen farms do significantly harm wild salmon offered the following opinions:

- Many stocks are still listed under the Species at Risk Act as "Of Concern," despite a massive reduction in commercial fishing.
- Given the other environmental threats to wild salmon (in both freshwater and saltwater environments), salmon aquaculture must take its share of the dislocation.
- Farming can impact the environment and, through those impacts, can have a secondary impact on wild fish populations.
- The salmon aquaculture sector has not been able to demonstrate that open-net pen farming poses little to no risk to wild salmon.
- Salmon farms located in the migratory pathway of wild salmon are a "smoking gun" in relation to the dramatic decline in stocks in nearby areas.
- While climate change is a serious issue for wild fish, not all west coast salmon populations are failing. Some populations that are away from fish farms, such as Alberni Inlet and Campbell River pink salmon, are thriving. Hydro-acoustics show

that fish are being lost somewhere around the east coast of Vancouver Island. This points to the fish farms as a stressor, and removing one or two stressors will help wild fish fare better against other stressors like climate change.

- BC must move toward a regime where Atlantic salmon do not have the ability to interact with wild Pacific salmon through escapes, and where farms do not impact wild salmon through fecal waste, antibiotics, pesticides, and other factors. All these problems must be contained within the farmed salmon habitat. Open-net pen salmon farming is currently polluting the ecosystem.
- At least 13 studies have been published in peer-reviewed journals showing the increase in sea lice from farmed salmon driving pink, coho, and sockeye toward extinction. Sea lice in southern BC open-net pens are a huge problem.
- The biggest mortality for smolts is the early marine phase. Most juveniles use the same areas year after year. The impact of hundreds of thousands of fish in these areas is extreme.
- The precautionary approach is the only approach for BC.
- Mouth rot is another threat to wild salmon. New information shows that it causes considerable risk to coho, chinook, and sockeye.

Those who said that open-net pen farms **do not** pose a risk of significant harm to wild salmon offered the following opinions:

- There is no solid scientific information linking open-net pens directly to any negative impacts on stocks of wild salmon—including sea lice and piscine orthoreovirus (PRV).
- It does not make sense to link the rebuilding of fish stocks with transitioning from open-net pen farming. Other environmental and human stressors would need to be addressed if wild salmon populations are going to recover.
- Interactions between wild and farmed salmon are not significant.
- Disease transfer between aquaculture and wild fish in BC is not significant enough to warrant closing down open-net pen farms.
- While BC and Alaska have seen wild salmon catches reduced catastrophically, other locations in the world, like Russia, are seeing historically high commercial catches. One hypothesis is that a climate-related ocean effect has led to a regional decline in the carrying capacity of the coastal BC waters.
- There is enough area along BC's coastline to support the continuance of marine net-pen salmon farming.
- Salmon runs were already decreasing before fish farms were set up along the coast.
- The west coast cannot be compared with other regions in relation to some issues. Issues with diseases in other regions are not mirrored in BC. For example, Norway's issues are mostly viral and production-related, while BC's issues are mostly bacterial.
- DFO data from 2018 on the monthly mortality attributed to infectious disease showed that the risk of pathogens potentially spilling over to the wild is less than 2.5 percent per month.
- Sea lice have been monitored for two decades in the Broughton Archipelago, and during most years the majority of pink and wild salmon migrating through the archipelago have no sea lice on them, or just one.
- Science proves that with measures in place—such as noise limits in water, surveillance for pathogens and monitoring of the environment—the residual risk is acceptable.
- Climate change, industrialization, and carbon emissions are key factors in the decline in salmon.
- More studies are needed on the effects of light on salmon (wavelengths affecting wild fish).

SIGNIFICANCE OF WILD PACIFIC SALMON TO COMMUNITIES AND FOR RECONCILIATION

Regardless of their position on open-net pen salmon farming, participants agreed on the importance of rebuilding wild Pacific salmon stocks. A number of comments were made on the significance of wild Pacific salmon to communities:

- Wild salmon are an iconic BC species and are important to the social, environmental, and economic fabric of BC coastal communities.
- Wild salmon are essential to the spiritual, cultural, and economic well-being of BC First Nations and are part of their traditional diet.
- Pacific salmon are a "keystone species."
- Fishing communities such as Port Hardy and Prince Rupert used to be vibrant, active communities, but are now a shadow of what they were, due to the decline in abundance of wild salmon stocks.
- A rebound in the health of wild Pacific salmon would rejuvenate the vitality of commercial and recreational fishing and of First Nations communities that use wild salmon for food.
- Salmon farmers are passionate about protecting and preserving wild salmon stocks and stand behind initiatives to support these efforts.
- Wild salmon have a large significance, but so does salmon aquaculture. Farmed fish are an important food. One should not eat or fish wild Pacific salmon because they are endangered animals.

ECONOMIC SIGNIFICANCE OF WILD PACIFIC SALMON

Wild Pacific salmon were discussed as a resource for the commercial fishing sector, First Nations fishing and food, and sport fishing tourism. In all these areas the decline in abundance of salmon stocks has had a significant impact.

Commercial fishing

Participants discussed the importance of the commercial fishery in BC, the decline in salmon populations, and the sacrifices that had been made to protect remaining stocks. Some participants said that in its current state, the wild salmon population can no longer support a commercial fishing industry.

In spite of the challenges the commercial fishery has faced, its economic importance along the BC coast was still emphasized. With the potential added value of processing within Canada rather than in other countries, as is currently the practice, the potential economic value could be increased exponentially. It was suggested that the BC competitive advantage in the global salmon industry could best be supported through a federal commitment to rebuilding wild Pacific salmon and sustaining the local ecology, which would rejuvenate the wild salmon fishery as well as the tourism industry—particularly sport fishing.

Conversely, several participants said that wild salmon fishing is currently being managed too conservatively and there is no opportunity for in-season management decisions that would allow for larger catches when there is a surplus in the stock. When runs exceed native spawning requirements for one species, the fish may go unharvested due to federal policies related to other species of salmon. This limit is unwarranted, it was suggested, and commercial fishers are being unfairly impacted. A "made in BC" solution would allow for better regulation of wild salmon harvesting.

One suggestion was that DFO speed up research on mark-selective fishery management and use mass marking to learn more about stocks. This would provide information on where different species spend time and how much they travel. Through mark-selective fisheries, species that do not travel much could provide benefit to communities once they reach minimum legal size.

Recreational/sport fishing

One participant reflected on the enormous success of the recreational fishing sector in decades past, recalling that in the 1980s, Campbell River was the sport fishing capital of the world. But after more than 20 years of not catching Coho, the salmon population has not come back. Although the participant expressed hope that removing open-net pen farming would help, they noted that with many factors at play there is no certainty that the Strait of Georgia Coho population will improve.

Another participant expressed optimism that the wild salmon economy could return, and said that the tourism industry focused on recreational and sport fishing could be rejuvenated and become an important sector in BC if wild salmon stocks are rebuilt.

FACTORS TO CONSIDER IN PROTECTING AND REBUILDING WILD FISH STOCKS

Restoration of wild salmon

Many participants shared their views that wild salmon are in a disastrous state and said that habitat restoration efforts and enhancements need to address broad areas ranging from climate change to habitat restoration. Some participants suggested that all wild salmon fishing should cease until wild stocks improve.

Participants made the following recommendations regarding restoration of wild salmon and their habitat:

- Involve multiple orders of government.
- Focus on rehabilitation of estuaries, rivers, and streams. Protect and restore habitat and spawning grounds.
- Renew wildlife management programs that employ scientists and others to count fish and monitor natural areas.
- Revamp forestry practices to protect spawning habitat.
- Limit commercial and recreational fishing, and stop ocean ranching in Alaska.
- Ensure there is no illegal or unregulated fishing of wild stocks, including internationally.
- Create a generational plan for wild Pacific salmon, and a generational investment, as a shared responsibility among all governments and partners in the process. Hire people to implement the policies.
- Address pollution sources in BC’s rivers.

Financial support for rehabilitation

It was suggested that the government should invest more heavily in rehabilitating wild salmon stocks. Several participants advocated for grants to support enhancement work and wild salmon restoration. While the BC Salmon Restoration and Innovation Fund (BCSRIF, a $100 million federal–provincial grants and contributions program) was mentioned as a good start, participants said that investment must be increased exponentially to support wild salmon restoration, and made several suggestions:

- Provide continued support through mechanisms such as grants and enhancement work.
- Use revenues from carbon credits for rebuilding wild salmon stock.
- Require forestry companies and others who use local resources to contribute to salmon restoration.
- Invest in research on migration routes and timing.
- Provide funding for small-scale enhancement efforts and watershed monitoring activities.
- Support initiatives for marine debris cleanups in salmon corridors.

Policy, regulatory requirements, monitoring and enforcement

Some participants called for policy and planning that would support the restoration of wild Pacific salmon, including a "generational plan" for wild Pacific salmon and better implementation of existing policy such as *Canada's Policy for Conservation of Wild Pacific Salmon* and the *BC Water Sustainability Act.*

Discussion of additional regulatory aspects to consider for protecting and rebuilding wild fish stocks is summarized in the "Governance considerations" section of this report.

SECTION 4

Encouraging investment in BC aquaculture

Discussing BC's competitive advantage and how to improve upon it, participants spoke of the network of businesses and expertise that supports the industry, the technologies and practices developed in BC waters and exported around the world, and the pristine environmental conditions. There were different views on whether BC would continue to have a competitive advantage in farmed salmon production if communities transition from open-net pen farming. Some participants expressed the view that BC's competitive advantage had already been lost with recent policy decisions that have cooled industry interest. Others had suggestions for how to encourage investment in the sector.

IMPROVING CERTAINTY FOR COMMUNITIES AND INDUSTRY

Uncertainty—specifically regarding the regulatory environment—was cited as a key factor that is stalling plans for business activities and new projects, including plans for collaborative research and foreign private investment. In particular because of the growth cycle of salmon, it was emphasized that companies need certainty over a period of years so that investments can come to fruition.

One question put forward was when the federal government would create a more comprehensive aquaculture policy to serve the sector. Participants said that unless industry could see a clear path forward for growth in BC, it would be difficult to make investments. One broad policy recommendation was for Canada to create a federal Aquaculture Act that provides clear and consistent policies, procedures, and operating models for the salmon farming industry. This would foster confidence and drive innovation. It was suggested that financial incentives are less important than security of tenure, certainty in regulation, and a vision for aquaculture in Canada. Another complementary suggestion was to make a federal commitment to the Blue Economy platform signed by the Prime Minister in 2020.

Participants also suggested identifying a conclusive decision-making process with a clear path forward and a recognized place for everyone. The federal government should clearly define sustainability in relation to aquaculture and articulate its priorities in relation to fish welfare.

REGULATORY STRUCTURES AND RISK TOLERANCE

Optimizing the regulatory environment

Regulatory challenges were cited by some as a barrier to innovation. Several participants emphasized that industry needs clarity from government on which specific environmental issues need to be addressed, so that they would know what type of solutions to invest in.

Participants also called for a clear regulatory structure and reporting framework, ideally with a single point of access that would eliminate fragmentation among multiple regulatory agencies.

They also said that there should be long-term alignment of all orders of government (federal, provincial and local).

Some international examples were shared for how to make regulatory processes more efficient to reduce timelines from application to operation. One participant explained that Mexico allows companies to obtain a start-up permit enabling a short-term pilot project that serves as proof of concept. Once the project is shown to do no harm, one can apply for a larger commercialization permit. Norway was offered as an example of a country with an efficient permitting process where the time between applying for a licence and putting fish in the water is just four months. Six months was mentioned as a benchmark for a timeline that would be globally competitive.

Participants made several recommendations for optimizing the regulatory environment for investment in BC aquaculture:

- Identify a government champion to help with fast-tracking the regulatory process, getting clear policy support, and developing a framework to encourage participation.
- Streamline, clarify, and expedite the permitting process, and shorten the timeline. Having knowledge of all the technicalities up front can reduce the time to cash flow for a new site developer.
- Expedite environmental assessments.
- Take care to resolve regulatory issues without compromising the environment.

Risk tolerance

Risk tolerance was cited as an important consideration for innovation. The level of risk tolerance—for companies and regulators—can block or support innovation. Some innovations will fail, and there needs to be flexibility in the system to allow for failure. If a company tries something new and it fails, causing it to violate regulations, that failure should be a practical issue and not a legal issue, said a participant.

LOCAL CONDITIONS, INFRASTRUCTURE AND WORKFORCE

Participants from companies listed some of the key considerations when evaluating whether a local area is attractive for aquaculture investment:

- Access to clean water appropriate for the technology (e.g. high-salinity seawater)
- Sufficient and reliable power
- Bricks and mortar infrastructure
- Supply chain infrastructure
- Proximity to markets
- A specialized workforce (the level of training sought varied—some companies had their own training programs)
- Social licence for the presence of the business or technology

For land-based operations, companies said they would need sufficient land area and would prefer to build on Agricultural Land Reserve (ALR) lands. One participant said that if the land was available at no cost (such as through a partnership with a First Nation) that would be attractive, and added that their company would like to set up a division of its land-based business with First Nations.

It was noted that several post-secondary schools already have programs to train an aquaculture workforce, including marine veterinarians—giving BC an advantage in providing qualified personnel.

LOCAL KNOWLEDGE AND RESEARCH CAPACITY

To leverage BC's existing knowledge base, it was suggested that the government provide long-term funding for research toward the development of new aquaculture technologies as well as monitoring and restoration of wild fish stocks. Other suggestions included creating a technical working group to advise the sector, and creating an institute dedicated to fish health (wild and farmed) and environmental stewardship.

It was suggested that UBC and SFU researchers could help with literature reviews and studies; however some participants observed that some of the scientists who had been working in BC to help the industry improve aquaculture have been lost—a situation exacerbated by the freeze on investment by many companies after the recent Discovery Islands decision. Another suggestion was to offer R&D funding to aquaculture businesses to develop new aquaculture methods and technologies in partnership with academic institutions.

GOVERNMENT INCENTIVES AND CATALYSTS

Several participants emphasized that although incentives are useful, at the end of the day any new technology must be viable in business terms—companies must be able to make a profit and be globally competitive. As well, one participant cautioned that there may be socioeconomic issues associated with offering government support for one production system over another. It was also noted that incentives should not be offered at the expense of the environment. However, there was general support for the concept of government incentives, which could facilitate the transition to more sustainable technologies, build trust with industry, and offset the challenges of transitioning from open-net pen aquaculture.

Participants made the following suggestions regarding government incentives and catalysts:

- Support small businesses, joint ventures, and cooperatives. Cooperatives allow for local ownership while also organizing for volume and scale. Support structures where local communities prosper not just through employment but through ownership, joint ventures, or profit-sharing.
- Increase fees or taxes for open-net pen farming and use the funds to subsidize more sustainable technology.
- Provide funding or support to help the industry, including Canadian companies, transition to alternative technologies for land-based or offshore salmon farming. Incentivize the first 5,000 to 15,000 tonnes of land-based production—for example, through loan guarantees or tax credits to improve the risk-return ratio. This incentive can be limited and defined, to kickstart the industry.
- To keep jobs along the coastline, fund the development of technologies for marine-based production or fund rural land-based farming.
- Make it easy for the industry to dissolve current agreements with local First Nations and move to land-based sites.
- Provide funding for innovation in alternative energy sources for farms, as well as feed alternatives.
- Provide direct funding for demonstration and pilot projects, for five to ten years. Support small-scale prototypes in collaboration with communities.
- Offer tax incentives, training incentives, labour rebates, and capital incentives early on, recognizing that aquaculture is a capital-intensive business.
- Provide long-term loan guarantees.
- Indicate clearly what types of technology will be supported, to help guide investment decisions.
- Favour technologies that are environmentally friendly and friendly to fish welfare, while enabling farmers to increase production.
- Champion access to global genetics for Atlantic salmon raised in land-based farms, to help in producing higher-performing fish.
- Support the BC aquaculture industry in becoming a major supplier of cultured seafood around the world. Promote sustainable BC salmon and seafood both domestically and internationally as a quality product.

INTERNATIONAL MODELS: INCENTIVIZING INNOVATION AND LEVERAGING KNOWLEDGE

There was some discussion of various international models for incentivizing innovation in aquaculture. One participant described an EU program that provides financial support to cover a portion of the capital costs for the construction of land-based facilities. Other international models for incenting innovation in aquaculture were shared by individuals from Norway and Scotland.

Norway

Several people described the Norwegian system, where the government prices licences lower for those who are testing out new methods of fish production and rewards companies with licences to increase production if they have an innovative idea that could have a positive environmental impact. If the idea does not work, the company is still allowed to keep the licence as a reward for investing in innovation.

It was also suggested that Norway has a good model for using research to inform policy and regulations, funding that research with taxes from the industry. The country's traffic light system was mentioned as an innovative way of managing the growth of aquaculture.

CtrlAQUA, a Norwegian centre for research and innovation, explained that their recommended strategy is to prioritize long-term innovation R&D, collaborate closely with industry, and collaborate with end users and groups that have concerns. It was suggested that Canada could connect with Nofima, a Norwegian research institute, to explore options for joint research projects focused on advancing closed containment technology in BC.

Scotland

The Scottish government explained that the Sustainable Aquaculture Innovation Centre (formerly the Scottish Aquaculture Innovation Centre) supports the drive to enhance aquaculture sustainability. It helps to bring different groups together and apply the latest science to drive sustainable growth through innovation. The sector leads the way in identifying and developing technological innovation that will enable future sustainable growth, with government, academia, and other agencies supporting those endeavours through appropriate incentives.

Scotland indicated that it already enjoys good collaboration with Canada through the Quadrilateral agreement of 2015 and plans to continue this relationship.

SECTION 5

Technology and Innovation

EXISTING AND NEW TECHNOLOGIES OF INTEREST

Participants discussed a variety of technologies and alternative methods of farming salmon—both land-based and marine-based. Several cited the 2019 report prepared by Gardner Pinfold Consultants Inc., *State of Salmon Aquaculture Technologies*, as well as the 2020 report and recommendations prepared by the Indigenous and Multi-stakeholder Advisory Body's Salmonid Alternative Production Technical Working Group, as useful resources. Views varied on the viability and sustainability of the various technologies. Some groups said that closed containment would be the only acceptable technology. Others favoured a combination of approaches that involves land-based and in-water farming. Some supported semi-closed containment, and some said that semi-closed containment could be a short-term solution during the transition, but with a clear stop date.

One recommendation was not to look to a single farming method as the solution, because a technology's appropriateness will depend on where and how it is implemented. The participant also advised against referring to specific technology in government regulations, since technology is evolving faster than the regulatory process. Several people said that policies should prioritize results over the method by which they are achieved.

International knowledge and experience

The Scottish government shared its observations regarding innovation in Scottish aquaculture, commenting that further investment is expected in a number of areas: reducing sea lice loads, trialling snorkel nets, waste capture systems, sustainable cleaner fish, offshore technology for higher energy sites further from the coast, producing super smolts to reduce interaction time at sea with wild salmon, and combatting disease on farms.

The Scottish government commented that closed containment technologies (land or marine) may solve certain challenges but can introduce their own unique set of potential issues, particularly with regard to energy requirements, water quality, water chemistry and dissolved gas management. A great deal of R&D investment is required, and the larger Norwegian-owned companies are working on proof of concept in Norway.

CtrlAQUA, a Norwegian centre for research and innovation, commented that in Norway the idea of growing salmon to market size in land-based closed containment is quite new, with only one such facility in operation (i.e. Fredrikstad Seafood). They indicated that many projects are at different stages in the pipeline, but the technology will need to be proven successful before others jump in.

Land-based closed containment systems[4]

Some participants expressed the view that land-based aquaculture, featuring the recirculating aquaculture system (RAS), was a good alternative to open-net pen farming, while others expressed doubt that it was economically or environmentally sustainable. It was noted that there is an upsurge of investment interest in land-based aquaculture, with the technologies moving from the vision/model stage to the operation of scaled production systems (e.g. in locations like Florida and Maine). Some mentioned that land-based operations currently exist in BC, are showing promise and can be profitable, but it was also suggested that Canada was "missing the boat" by not moving fast enough to foster this form of aquaculture as industry is currently ready to invest.

Others expressed the opinion that, to date, this technology is either still at the planning stage or, if in operation, not yet proven. Some expressed concerns about environmental impacts, and doubts about the economic viability of this type of system, particularly in the small communities of Vancouver Island. It was noted that the viability of land-based aquaculture depends on available land area. The operations will require land and will be visible, and this may be in conflict with other interests, such as tourism and recreation. The time required to implement land-based aquaculture was another issue, with lengthy steps needed including finding sites, designing and building facilities, and getting them up and running.

Marine-based systems

Participants discussed several forms of marine-based aquaculture: **offshore aquaculture**, **semi-closed-containment systems**; and **marine closed containment systems**.[5]

Many emphasized the importance of ensuring that any new technology would mitigate interactions between farmed and wild salmon.

Offshore aquaculture

Some participants remarked on a lack of clarity about what is defined as "offshore" (i.e. how far an operation would have to be from shore to fit into this category). While the technology is developing fast, some said it was not clear whether it was logistically feasible or had been commercially successful, and cited the need for significant infrastructure to support operations at sea. Others said that offshore farming options would be more likely than land-based aquaculture to benefit local communities that currently use open-net pen farming and were "more realistic" than land-based options at this point.

One participant described an open-ocean aquaculture system featuring submerged pens spaced apart and located 12–15 km offshore. This system uses real-time automation to monitor the pens from a distance, including biological factors, at a six-kilometre radius around the area. The company's monitoring of the area around the pens has shown no negative impacts from the farm. It was described as a financially sustainable model. This technology is currently being used for warm-water species, and has not been tested in cold waters.

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[4] **Land-based recirculating aquaculture systems (RAS)** involve growing salmon in recirculating tanks in closed-production facilities on land. (*Salmonid alternative production technologies technical working group report and recommendations*, 2020)

[5] **Floating semi-closed containment systems** are marine-based, feature a walled-barrier, pump water from depths, and do not capture all waste. There are various designs. **Offshore production** "is defined differently across the globe; however, it is primarily defined by a high level of exposure and lack of protection from land masses, rather than a predetermined distance from shore. The variety of designs include open and semi-closed systems, floating and submersible options, as well as fixed and mobile systems." (*Salmonid alternative production technologies technical working group report and recommendations*, 2020)

Semi-closed containment

Some participants suggested that these floating technologies are in the early stages of development, and some suggested the upfront capital costs for building these systems are higher than with fully contained marine facilities. While proponents said that semi-closed containment operations were a good alternative to open-net pen farming, others maintained that they could not promise to contain parasites and diseases.

Participants discussed the development of semi-closed containment systems in Norway and Australia, where they said the technology has become more viable and commonplace and the cost is significantly lower compared to the land-based RAS system. One suggestion was that semi-closed containment could be used to open the northern coast of BC to salmon farming, as water temperatures rise along the west coast of Vancouver Island, making those waters inhospitable to salmon.

One company described an example of a semi-closed containment system that features buoyant, durable pens lined with ultra-strong polymer. Viral risk is greatly reduced by collecting the saltwater for the pens at significant ocean depth, maintaining oxygen and temperature levels, using healthy stock, and vaccinating. The system also avoids lice. The pens have a sediment trap at the bottom that captures 90 percent of sediment, and then the effluent is pumped for water treatment.

Closed containment (marine)

One suggestion was that in-water closed containment technology could be used as part of a responsible plan to transition, providing there are standards for no interaction with wild salmon and zero effluent mixing. This would have to be monitored in a quantitative way.

One new technology described by a participant involves a closed-containment eggshell barrier that would separate wild and farmed fish. Cold water is pumped into the closed-containment shell, with water exiting through the bottom of the eggshell barrier. The effluent is intended to sink into the deep-water column.

Hybrid systems[6]

Some participants expressed positive views on hybrid systems as a way to create a more sustainable industry that still has a place for open-net pens:

- The risks associated with open-net pen farms could be reduced through a "big smolt system" where smolt are grown in land-based facilities or floating semi-closed containment systems until they are bigger (e.g. 800 grams) and then transferred to the open-net pen farm.
- RAS technology makes it possible to produce big smolts and ultimately increase the biomass produced without changing the licence size, by reducing the amount of time fish spend in the water.
- Producing big smolts requires a combination of land-based and in-water farming. Government can bring value to the industry by facilitating communication within the industry to share knowledge.

[6] In a **hybrid system**, post-smolts are produced "in land-based RAS or floating semi-closed containment systems before the salmon are transferred to traditional marine-based net-pens for grow-out to market-size." (Salmonid alternative production technologies technical working group report and recommendations, 2020)

Other technologies

Other technologies and features of interest included: zero-effluent designs and aquifer-only water intake; enhanced growth; disease resistance; plant/insect-based feeds; remote feeding and monitoring systems; low-carbon technologies for moving water efficiently; feed and vaccines to reduce antibiotic use and impacts on wild fish; wind and solar power; hydro turbines; genomic technologies for fish health, sea lice resistance and adaptation to changing conditions; and waste capture and recycling.

Innovation in open-net pen technologies

It was suggested that the BC aquaculture industry has made significant improvements in addressing risks to wild salmon, and has designed solutions that have been exported to other countries. Several technologies and practices were discussed that could better protect wild salmon from the impacts associated with open-net pens, such as using an artificial protection barrier and better maintaining oxygen levels in pens.

ENVIRONMENTAL CONSIDERATIONS FOR ALTERNATIVE TECHNOLOGIES

General concerns—environmental impacts and mitigation strategies of alternative technologies

Participants discussed the fact that removing open-net pens would mean developing new aquaculture systems, which could involve new pathogens and parasites, new physiological issues of interest in the farmed fish, and new potential impacts on the environment. Research would be needed and new tests would need to be developed. This is a long-term process, some said.

A key concern was effluent. Some participants stated that no aquaculture system (land-based or marine-based) currently treats its effluent, resulting in waste, pathogens, and diseases still being transmitted to the wild—but others mentioned systems in use now that are treating effluent before discharging it. Participants called for research and risk assessments on ocean discharge of effluent, saying this must be done before the permitting process begins so that the industry can grow confidently.

Some people had suggestions for dealing with effluent from various types of aquaculture operations, such as monitoring, filtering, and treating it.

Land-based closed containment systems

Some participants expressed strong views that land-based aquaculture is not advisable from an environmental point of view and may have unintended consequences on land ecosystems.

Several concerns were raised:

- Land-based aquaculture has a large footprint. It would result in massive land clearing and would use a large portion of Agricultural Land Reserve (ALR) land.
- Most land-based facilities use freshwater rather than saltwater—a limited resource. Alternatively, using saltwater and discharging the effluent on land leads to other problems.
- Land-based facilities need considerable power, at a time when communities need to reduce their carbon footprints.
- Land-based aquaculture would shift the industry toward a feed lot model when other agricultural sectors are moving away from it.
- Atlantic salmon are living sentient beings and should be raised in their natural environment.
- Large land-based aquaculture systems will lead to biological and water issues, such as waste stream problems.
- If an environmental issue is discovered and a land-based facility needs to be decommissioned, restoration of habitat will take much longer than when an open-net pen fish farm is removed.
- Importing eggs from other countries risks bringing in viruses and pathogens. This risk can be partially mitigated by starting the eggs in an intermediary, closed site away from the

main site, to ensure that no disease is spread. The Canadian Food Inspection Agency, as the gatekeeper for imports, should be involved in consultations.

Several participants commented that salmon farmers who work outdoors have the opportunity to stay connected to the local ecosystem and act as stewards for their regions. Moving salmon farming to land-based facilities would change the nature of the experience for the farmers and for the salmon. Salmon farmers would lose their connection to nature and would become system operation managers in a facility where everything is automated. This is a totally different kind of aquaculture, they said.

Others said that land-based aquaculture is the best alternative to open-net pen farming, and made the following points:

- Land-based systems would have more options for effluent treatment and would avoid polluting the environment with pathogens and disease.
- Initial studies on land-based farms assumed they would be powered by coal, not hydro power, and did not consider the total amount of fuel used by open-net pen farms nor the methane emissions from unprocessed fish feces. These studies miscalculated the carbon impact comparison between the two production methods.
- Researchers are working to develop ways of collecting and processing effluent, prevent sludge production and improve water treatment methods.

Some initial suggestions were made for mitigating the environmental impact of land-based aquaculture:

- Governments should build upon existing provincial regulations, like those protecting migratory bird nests and raptor nests, to protect terrestrial ecology.
- Agriculture and aquaculture should be separated with regard to ALR land use.
- Regulations can be implemented to require the implementation of technological solutions to reduce power consumption. These solutions exist but currently cost more.

Marine-based systems

Sustainability of marine aquaculture as a food source
Several participants remarked that marine aquaculture is the least carbon-intensive source of animal protein and an important part of meeting the protein requirements of a growing world population.

Others said that farmed fish are not a sustainable food source. One view was that while the industry does produce a lot of food, it also consumes food in order to feed the fish, and any assessment of its benefit needs to take into account all the supply chain impacts. As an alternative, it was suggested that aquaculture could be used to grow other types of food, such as kelp, seaweed and shellfish.

Environmental impacts and mitigation strategies
Comments on the environmental impacts of various marine-based aquaculture systems focused on the different technologies and methods used, and factors associated with their location (such as depth of water and type of ocean current). The following comments were made:

- Closed-containment operations that pump effluent into the deep ocean cannot be placed in areas of high current where diseases and lice will circulate back up to the surface.
- Some semi-closed containment systems reduce the risk of disease spread by using separate units for different groups of fish (compared to the shared habitat of an open-net pen system).
- In some semi-closed containment pens, waste is trapped in a filter at the bottom of the pen and piped back to the top to be collected and dried. It can then be used as fertilizer, to make bio-gas, or even as a source for extracting protein. Treated wastewater is discharged at optimal depth.

- In semi-closed and closed containment systems, it is possible to control temperature, oxygen levels, and feed to reduce the likelihood of disease.
- One new technology disperses effluent into a deep water column, which should sink toward the bottom. However, more research may be needed to determine whether this effluent water would well up in some geographic areas.
- Offshore technologies could still carry many environmental risks, like fish escapes, disease, pollution, and noise pollution, and these risks should not be overlooked just because the operations are further out at sea.

ECONOMIC CONSIDERATIONS FOR ALTERNATIVE TECHNOLOGIES

It was noted that any new direction the sector takes would have to be a sustainable business model. Whatever options are implemented in place of open-net pen farming would have to be cost-competitive and profitable at scale. If local communities and First Nations are to benefit, the technologies would have to work well in those places. Meeting these requirements would make a technology a "real, not theoretical" alternative.

A key economic challenge mentioned was how to maintain production and economic benefits while directing significant capital investment toward a transition from open-net pen farming.

Participants discussed economic considerations for land-based closed containment, marine-based aquaculture (offshore, semi-closed and closed containment), and hybrid systems.

Global marketplace and industry direction

As salmon is a global commodity, one concern was that if cheaper forms of production exist, then the more expensive forms of aquaculture will be less viable. For example, some expressed the concern that with some countries still allowing open-net pen farming, it could be more difficult to compete using different aquaculture technologies in Canada.

It was suggested that Canada should move in the same direction as other countries, otherwise the transition plan may not be sustainable.

Participants raised some questions:

- Is there global leadership—for example, in land-based technology? Are there companies or countries that the BC industry could look to, that are setting the global direction for the sector?
- Should Canada pivot from being a global leader, and instead strategically target specialized markets?

Land-based closed containment systems

There was much discussion of the economics of land-based aquaculture, and a number of themes emerged:

- Impacts on small/remote communities: Many participants noted that, for logistical reasons, companies would build land-based aquaculture facilities close to major markets. In this situation, coastal communities and First Nations in BC would no longer be at the centre of things.
- New risks to farmed fish: Potential technological failures would be a new risk factor that could cause large fish mortality events. There are biological issues that may emerge that are unique to these facilities.
- Electricity requirements: For many, the cost (and environmental impacts) of electricity consumption was a concern. One point made was that land-based fish farming could only thrive in areas with low-cost electricity (in contrast to open-net pen farming). Others, however, said that there was an abundance of low-cost hydro power available.
- Profitability: Many stated that land-based aquaculture is not proven as a profitable model, or at least is a more expensive mode of production that is not globally competitive. Others said that some companies are investing heavily in land-based production and have had success. One participant said that capital

costs for open-net pen farms are spread out over time as the pens must be replaced, while land-based aquaculture requires large upfront capital investment but facilities last longer and conditions are easier to control.

- Economic models: One person outlined two economic models for land-based aquaculture: large-scale operations that produce about 10,000 tonnes annually, and small-scale operations that produce 100-1,000 tonnes annually. The latter can be coupled with aquaponic greenhouses for vegetable production. A BC operation producing about 1500 tonnes reported that they were getting a comfortable return on investment by starting at a manageable size and building a strong foundation focused on raising fish.

Some participants said that a key aspect of BC's competitive advantage—its coastal waters at the right temperature for salmon—would be lost if the industry transitions to land-based aquaculture. An alternate view was that the existing network of expertise and services in BC could easily be adapted to land-based aquaculture.

Marine-based systems (offshore, closed containment, and semi-closed containment) and hybrid systems

Discussions of marine-based systems focused on comparative costs of operating the different systems. Citing the 2019 Gardner Pinfold report, *State of Salmon Aquaculture Technologies*, one participant said that hybrid and marine closed containment systems are the most economically feasible alternatives to open-net pen aquaculture, stating that marine-based closed containment systems are one-tenth the cost of land-based aquaculture.

Some participants said that semi-closed containment pens are cost-competitive with open-net pen aquaculture, noting that although there are extra costs, these systems save money by avoiding lice problems, reducing fish mortality, and achieving a higher feed conversion ratio.

One person described an offshore system that was still being tested at beta sites, but showed promise to be a financially sustainable model. The company is creating the needed technologies as it goes along, and partnering with other innovative companies. He suggested that the land-based approach was "uninformed" and said taking a fish farm out of the water does not solve all the problems.

Other participants suggested that marine-based systems would be more appealing to consumers who are willing to pay more for a product that is more environmentally friendly.

Economic alternatives to salmon farming

Noting that aquaculture is not limited to salmon farming, several participants discussed successful operations growing other food and suggested that this sector could be expanded in BC. It was noted that the plan to transition from open-net pen salmon farming does not need to focus on salmon—other forms of aquaculture could be an alternate income stream. Several examples were given of food that can be grown in aquaculture environments, including trout, sable fish, scallops, mussels, sea urchins, seaweed and kelp, and water lentils. This could be a way of repurposing open-net pen operations, and in some cases could even contribute to carbon sequestration, said participants.

Others, while supporting the idea of other aquaculture enterprises, emphasized that this may help but will not replace the economic contribution of salmon farming in BC.

PARTNERSHIPS, CIRCULAR ECONOMY MODELS, AND WHOLE-SYSTEMS THINKING

One participant noted that an important global trend is the development of partnerships and joint ventures among different companies. Individual farmers cannot do everything by themselves, and partnerships enable the sharing of knowledge and expertise.

The “circular industry” model is becoming a global trend and is a key to sustainability, said another participant. This model focuses on making the whole value chain sustainable—not just the fish farming component. An example of a circular model would be a sustainable green industry aquapark that grows and processes the salmon as well as handling the feed production and processing the wastewater. This approach presents an opportunity for partnerships to leverage knowledge and maximize potential.

Environmental, Social and Governance (ESG) systems, or “whole-systems thinking,” was also mentioned as an important global trend. This concept recognizes that humans are not separate from the rest of the environment and companies are not separate from the places and communities in which they operate. A whole-systems approach is an underlying set of principles for investment that honours the fish, the ocean and the local communities.

SECTION 6

Governance considerations

LEGISLATIVE/REGULATORY ENVIRONMENT

Regulatory requirements, monitoring, and enforcement

Participants discussed some specific ideas for regulations, monitoring, and enforcement, particularly for the open-net pen salmon farms currently in place.

Predator populations and sea lice were both discussed as important challenges to wild salmon. It was suggested that enhanced regulatory mechanisms for marine-based aquaculture—and effective enforcement—are key to limiting the sea lice population in specific environments.

One opinion expressed was the view that DFO uses siting criteria for open-net pen farms as a surrogate for risk assessments. The participant said that while open-net pen farms are in use (active), DFO should be employing risk assessment strategies such as particle flow models (with a vector added to the model) to learn about the local area, rather than just applying siting criteria. According to the participant, risk assessment means knowing where the wild salmon are, where the juveniles are, and where the effluent water flows, then identifying the stressors for stock and monitoring those stressors. Siting criteria, said the participant, are not sufficient to address the threat to juvenile salmon by parasites and disease.

International regulatory standards

Representatives of the Scottish government shared insights on how they approach the regulation of offshore aquaculture. In 2018, Scotland launched the Salmon Interactions Working Group (SIWG), which included members from the aquaculture and wild fisheries sectors, local government, Scottish government, and other agencies. This group made more than 40 recommendations on matters such as regulation and licensing of fish farms and collection of data. The Regulators Technical Working Group (TWG), made up of experts and local authority representatives, developed an evidence-based practical framework tool for a regulator to use to assess risk posed by sea lice to wild salmon and sea trout. Scotland's Farmed Fish Health Framework (FFHF) focuses on three priority areas: the cause of fish mortality, the impact of climate change, and the development of treatments.

Scotland is working on a "modernized" approach to fish farming development within key regulators—SEPA (the Scottish Environmental Protection Agency) and Marine Scotland. The aim is a quicker, surer, and fairer regulatory regime, balancing the legitimate commercial needs of the sector with the health and welfare of farmed fish, the interaction with wild fish, and protection of the seabed and wider water environment.

SEPA will assess the environmental impacts of any finfish technologies proposed for use in the Scottish context within its current overarching regulatory framework. SEPA has also launched a new regulatory framework and sector plan for finfish aquaculture, including measures to improve environmental compliance so that the size of fish farms is better matched to environmental capacity. SEPA is developing its revised framework further, particularly with regard to how organic waste discharges from farms are regulated—which is a key issue for stakeholders.

Requirements for commercial fishing vs. finfish aquaculture

Several participants said that there should be a level playing field for commercial fishers and fish farms, with fish farms held to equivalent standards as those who catch wild fish. One concern was that fisheries harvesting wild salmon must account for every fish caught, while salmon farms are not held to a comparable standard when gauging their impact on wild fish. Another concern was that while salmon farms produce fish at lower cost than commercial fisheries, this does not factor in the real cost of the fish in terms of the impact on the environment. From this point of view, the perspective was that salmon farmers had an unfair advantage compared to commercial fishers.

GOVERNANCE MODELS AND MECHANISMS

The discussions touched on governance models and mechanisms in relation to fish farming. Participants discussed the appropriate federal, provincial and local roles, the diversity across different areas of BC, and the migratory nature of salmon across larger regions. One key consideration was the fact that BC is entering a new governance relationship with First Nations governments as it implements new legislation to align with UNDRIP.

The following general suggestions were made:

- Improve licencing regimes to protect wild salmon instead of industry.
- Include the Sparrow priorities within decisions surrounding Section 56(a) for transfer licences.
- Consult on a co-decision model with a tri-partite government-to-government process, including informed reputable advisors.
- Create a single agency (i.e. integrate the policies of the different orders of government).
- Involve First Nations from the beginning in creating and leading the governance structure. Refer to co-governance models such as the Marine Plan Partnership for the North Pacific Coast (MaPP).
- Adopt recommendations from the Salmonid Alternative Production Technologies Working Group May 21, 2020, report.
- Develop regulations in an unbiased way using science and broad consultation to increase social licence for technologies and help improve trust in DFO.
- Set up an independent science advisory group on ocean health, watersheds, salmon habitat, and other matters. Include Indigenous traditional knowledge. Have members write statements of bias upfront, and try to achieve a balance.

DFO, PROVINCIAL, LOCAL AND FIRST NATIONS ROLES IN GOVERNANCE

Participants discussed the many potential roles of different governments in overseeing aquaculture and wild salmon. There was support for relationship-building and collaboration between the federal and provincial governments and with local governments and First Nations.

One point made was that while DFO is responsible for Canadian oceans, if the aquaculture industry is licenced as both land-based and marine-based then the land-based portion of the industry would be regulated by the province. Proponents of land-based aquaculture suggested that it would be better handled as “agriculture” than as “fisheries.” It currently faces regulatory requirements that are irrelevant to the land-based industry, and can’t access relevant funding because it is not classified as agriculture.

Another issue discussed was the importance of clarifying and following protocols for engaging with First Nations on a government-to-government basis, which may vary for different nations. This is discussed in more detail under "*Advancing Reconciliation*".

A variety of suggestions were made regarding the roles of DFO, the province, First Nations and communities:

- DFO should not have the dual responsibilities of protecting ocean resources and overseeing the aquaculture industry. DFO's primary mandate should be to protect wild stocks. As suggested by Justice Cohen, DFO should serve as a regulator of aquaculture, not as a promoter of the industry.
- DFO should have a director of wild salmon who would play a leadership role in focusing on the health of wild fish.
- DFO should continue to have regulatory oversight over the use of oceans, but licencing should devolve to the province.
    - There could be community and First Nations involvement in licencing and decision-making.
    - Scientific information could be shared with the public before licencing decisions are made.
- Monitoring of aquaculture activities should be handled by the province or locally.
- An overarching provincial approach could be implemented on a regional basis.

LICENCING FEES AND OTHER RESOURCE FEE STRUCTURES

Norway's approach to licences and licence fees was discussed (where the Norwegian government auctions licences for considerable sums of money), with participants noting some factors that make it difficult to compare with Canada's current regulatory regime:

- This practice can result in multiple companies operating in the same areas, which could become complicated in BC because of relationships with First Nations. From this point of view, the Norway model would not work in BC.
- There are differences in the Canadian value chain compared to Norway, which account for the lower licence fees.
- In BC, community involvement is a major aspect of the sector. Large licence fees would not align with the vision of having First Nations involved in the sector, and could become an issue.

One suggestion was to examine the Alaskan fisheries system for fee structures. Other participants suggested that those benefiting from the natural resources should be asked to reinvest something into rebuilding habitat. This policy could extend beyond aquaculture to include ocean ranching, resorts, logging, commercial fishing, and sport fishing. It was also suggested that any funds raised through licences for aquaculture activities on First Nations territory should go back to those territories and not be directed toward outside organizations. One idea was that the federal government work with First Nations to determine a fair fee structure for industry use of land and oceans. Another suggestion was to "charge what is reasonable" for the impacts on the natural resource.

One observation was that the taxes paid by people working in the industry, and corporate taxes collected through the companies, represented value for government revenues as well.

AREA-BASED MANAGEMENT

There was considerable discussion of area-based management as a governance option for BC, with some participants saying that this approach suits BC because it allows aquaculture to grow differently in different places, minimizing conflict, and supporting diversification. The approach was praised for putting the focus on people and ecosystems rather than technology.

One point made was that area-based management should use Indigenous knowledge to inform decisions. Many First Nations emphasized the need for local management making local decisions for local benefits, and some said they wanted to do their own monitoring of farms located in their territories. It was noted that local decisions should reflect the idea that the ocean is not a dumping ground—care must be taken with what is put in and what is taken out.

Norway's local ecosystem approach to licencing salmon farming was mentioned as a good model. Building on that, one person suggested a structure for moving some of the responsibilities currently held federally to a local ecosystem structure where First Nations, communities, and the province would make decisions within defined ecosystems that are directly impacted. These responsibilities would range from consultation through site licencing and routine environmental monitoring. The federal government would issue leases and have broad oversight of the environmental monitoring. A body of scientists could provide information to communities to aid in decision-making.

Some participants cautioned that there were challenges with area-based management for aquaculture in BC, noting that with salmon migratory runs of thousands of kilometres, local decision-making could have an impact on other areas. Some said that the region should not move forward with area-based management if there was any chance of open-net pens remaining in the water. It was suggested that if area-based management is put in place, the federal government must still have jurisdiction over certain standards and regulations. From an industry point of view, one challenge with area-based management is that a company can find itself confined to specific areas.

Other suggested models for area-based management included Ireland's CLAMS (Co-ordinated Local Aquaculture Management Systems), the Cowichan Round Table, and the Somass Salmon Harvesting Round Table.

APPENDIX

Suggested further research

Many participants cited existing resources like the Cohen Commission report, the Gardner Pinfold report, the report and recommendations by the Indigenous and Multi-stakeholder Advisory Body's Salmonid Alternative Production Technical Working Group, and the extensive work done by DFO scientists as important resources. Some people also suggested that more information is needed, and many of these suggestions are summarized here. A more extensive list of resources was collected through web-based and email submissions and all the material will be taken into account to inform further engagement and preliminary analysis in the development of a responsible plan to transition.

Relationship between open-net pen salmon farming and wild Pacific salmon

A number of recommendations were made about ways to gather additional information and make determinations on the relationship between open-net pen farming and wild salmon:

- Identify the specific risks to wild salmon that would be addressed by removing open-net pen farms.
- Obtain baseline data and do appropriate testing and follow-up to determine the actual impacts on both wild and farmed fish, once open-net pen farms are removed from an area. Assess the outcomes of various measures and publish the results.
- Gather data from the Broughton Archipelago and Discovery Islands now and annually, to measure the return of salmon stock in the rivers (particularly juvenile salmon going up-river) and evaluate the impact of removing open-net pen farms.
- Do further research on the effects of fisheries on wild stocks, to investigate declines in fish stocks that do not pass by fish farms.
- Learn from researchers who are looking at wild salmon migration routes to understand whether outmigration routes can be varied, and how to minimize interactions.
- Review the CSAS risk assessments, which some feel were not done objectively and could be improved upon. These were focused on a specific pathogen in a specific region for a specific population, using existing data. Current impacts on salmon may be the result of several factors combined.
- Listen to the full range of views held by all DFO scientists, and not just the "squeaky wheels."
- Create a three-person advisory council in which all the members must be approved by both sides of the debate (rather than having one member endorsed by one side of the debate, one endorsed by the other side, and a third member "in the middle").

Developing a responsible transition plan

The following suggestions were made for further research that would be useful in developing a responsible transition plan:

- Review the benefits, impacts, and costs of various finfish aquaculture technologies with a critical lens.
- Assess the cumulative impact of sea lice and pathogens/disease on wild salmon.

- Do "whole life cycle" studies of Pacific salmon to determine the impacts of open-net pen farming on wild salmon in the ocean, and where in their life cycle the impacts are occurring.
- Do more research on the local coastal carrying capacity.
- Use the regional expertise from the Broughton area to support the removal of open-net pens.
- Improve trust by conducting PRV challenge studies on all five species of wild salmon.
- Research best practices in other jurisdictions.

New production systems

Suggestions were made for useful research on innovation and alternate salmon farming technologies:

- Research all the costs of different modes of salmon farming.
- Explore animal health and welfare issues associated with new technologies and environments, including recirculating aquaculture systems.
- Look into alternative feed sources.
- Be aware of potential future innovations in the sector.
- Explore potential sites for land-based and offshore aquaculture operations.
- Identify priorities for future research based on information gaps identified during this engagement and transition plan process.

Some participants discussed the research and training that would be needed to adopt new production systems, adding that significant funding would be needed for these aspects of the transition plan:

- Training in sample and data collection.
- Identification of new data sets for monitoring conditions and fish health (e.g. to monitor specific diseases and parasites of concern in new growing environments).
- Development of new tests and analysis for the new data sets, and conversion from research-level tests to diagnostic-level tests so that they can be widely adopted.

Resources for research

Participants also discussed the resources needed to support this research, making some specific recommendations:

- Provide funding for "whole life cycle" studies.
- Fund a large-scale closed-containment farm to test the feasibility of the technology.
- Have a funding mechanism that supports fruitful research collaborations between academics and companies to optimize fish health and production.
- Create platforms in BC where industry members can meet and learn. Government can bring value to the industry by being a host and facilitator, and as a participating partner that is also learning.
- Provide support for pilots of area-based management to develop nation-led and community-supported decision-making, with strong local relationships between operators, nations and communities.

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Executive Summary

Purpose

There is strong interest from government, industry, non-government organizations and Indigenous peoples to accelerate the adoption of salmon aquaculture technology that minimizes environmental impacts in British Columbia, while supporting rural economic development, employment, and the security of Canada's food supply.

Background

Globally, there are two primary drivers of new salmon production technologies, namely: 1) pressures from governments and stakeholders to adopt more environmentally friendly technologies, and 2) challenges such as sea lice and algal blooms that affect salmon production. The industry has largely focused on improvements to conventional marine netpen systems to improve environmental performance while maintaining operational and financial feasibility, but new alternative production system technologies are advancing to meet these needs.

Indigenous communities

Indigenous communities have a key role to play as they already contribute at least 10% of Canada's aquaculture economic activity and are engaged in every aspect of the salmon farming value chain. They have played a central role in new technology developments including the Kuterra land-based RAS project. Furthermore, the Government of British Columbia adopted a policy in 2018 whereby, starting in 2022, the Province will grant tenures only to fish farm operators who have negotiated agreements with the First Nation(s) in whose territory they propose to operate.

Approach and scope

This report highlights Canadian developments along with a global scan of major technological advancements in four production systems that offer new opportunities for producing market-sized salmon:

- **land-based** recirculating aquaculture systems (RAS),
- **hybrids** involving land and marine based systems,
- **floating** closed-containment systems (CCS), and
- **offshore** open production systems.

Other technologies that support the main production systems are discussed including: sensors and control systems, data analysis for "intelligent farming", feed innovation, transport and logistics, nets and mooring, robotics, and broodstock development.

State of development

The current global status of the four production technologies is described briefly to illustrate key features, current production capabilities, indications of planned and actual commercial scale operations, key requirements for successful deployment of each system, and on-going areas of research that aim to address remaining challenges.

B.C. meeting requirements
There are valuable assets in B.C. that serve as a foundation for developing these technologies including: the well-developed aquaculture industry with transferable expertise, research and training capabilities, fish health and diagnostic capacity, supply chain inputs such as feed sources and distribution of products to markets, as well as the biophysical advantages of coastal B.C. More specific site requirements such as saltwater and freshwater resources, access to low carbon grid-connected power, road and communication networks, waste discharge and processing options are also discussed. Overall, B.C. is well-positioned for existing salmon farmers and new industry entrants to successfully develop these technologies.

Assessment of strengths, weaknesses, and uncertainties
The four production systems are evaluated across seven (7) environmental criteria, three (3) social criteria, and seven (7) economic criteria. These represent key requirements that must be met for salmon production volumes in B.C. to resume historic growth trends. The assessment reflects the broad state of technologies rather than specific designs, and uncertainties are noted as some technologies are yet to be proven commercially and applied in B.C. All four systems offer multiple improvements over today's conventional netpen production systems, however each system offers different advantages and disadvantages in terms of environmental, social, and economic performance. Land-based RAS and hybrid systems are the two technologies ready for commercial development in B.C., while floating closed containment requires 2-5 years of further review, and offshore technologies may require 5 to 10 years of review.

Development path in B.C.
Several things need to be aligned in order to promote innovation in Canada and to position B.C.'s salmon aquaculture sector for growing global seafood export opportunities. In general, national legislation and policy needs to clarify the requirements for aquaculture in terms of environmental and social performance and this will send the appropriate signals for investors to develop the technologies that meet the challenge. There are other requirements specific to each of the four production systems and these are discussed in order to attract and stimulate industry investment.

Incentives to build innovation in Canada
A number of measures are suggested for nurturing innovation based on what has taken place in other countries that are leading technology advancements. Some examples are development licences with reduced fees, marine sites with biomass allocations for innovative technologies, guaranteed loans, accelerated capital depreciation, along with research and development funding models that combine industry, government, and academia contributions.

1. Introduction

1.1 Background

There is strong interest from government, industry, non-government organizations and Indigenous peoples to accelerate the adoption of salmon aquaculture technology that minimizes environmental impacts in British Columbia, while supporting rural economic development, employment, and the security of Canada's food supply.

This interest extends beyond the province and is shared internationally across salmon producing countries. There are two primary drivers of new salmon production technologies, namely: 1) pressures from governments and stakeholders to adopt more environmentally friendly technologies, and 2) challenges such as sea lice and algal blooms that affect salmon production. The industry has largely focused on improvements to conventional marine netpen systems to improve environmental performance while maintaining operational and financial feasibility, but new alternative production system technologies are now advancing rapidly.

As concerns with conventional netpen systems were not fully addressed, expansion of salmon aquaculture slowed in recent years. Since 2000, the average annual growth in production volumes nearly stalled both in B.C. and globally (Figure 1) as limited opportunities for conventional aquaculture expansion were available. Space for marine netpens in some jurisdictions are fully utilized and governments have not increased the number of sites or biomass stocking limits at existing sites (e.g. New Brunswick). In other jurisdictions there have been moratoriums on allocation of new sites even though space is available, while comprehensive reviews were undertaken to establish new approaches for salmon aquaculture development (e.g. Nova Scotia).

While the pace of growth slowed, demand continued to grow. This bears out in rising prices reflecting the tension between demand and supply of farmed salmon products. Since 2000, prices for major markets including Europe, Chile, and North America have all climbed (Figure below).

Two factors continue to apply upward pressure on demand: 1) the stagnation in global fisheries catch, and 2) the rising global population including a growing middle class in many countries. World capture fisheries landings have been flat since the mid-1990s as numerous fisheries reached unsustainable levels (Figure 3). There are no near-term prospects for increasing fisheries catches, however aquaculture production (all products) climbed since the 1990s and farmed fish volume surpassed captured fish volume for the first time in 2014 (FAO, 2018). Additionally, the global population is expected to reach nearly 10 billion by 2050 (2 billion more than today; FAO, 2018) and there will be strong demand for aquaculture products as a valuable source of protein.

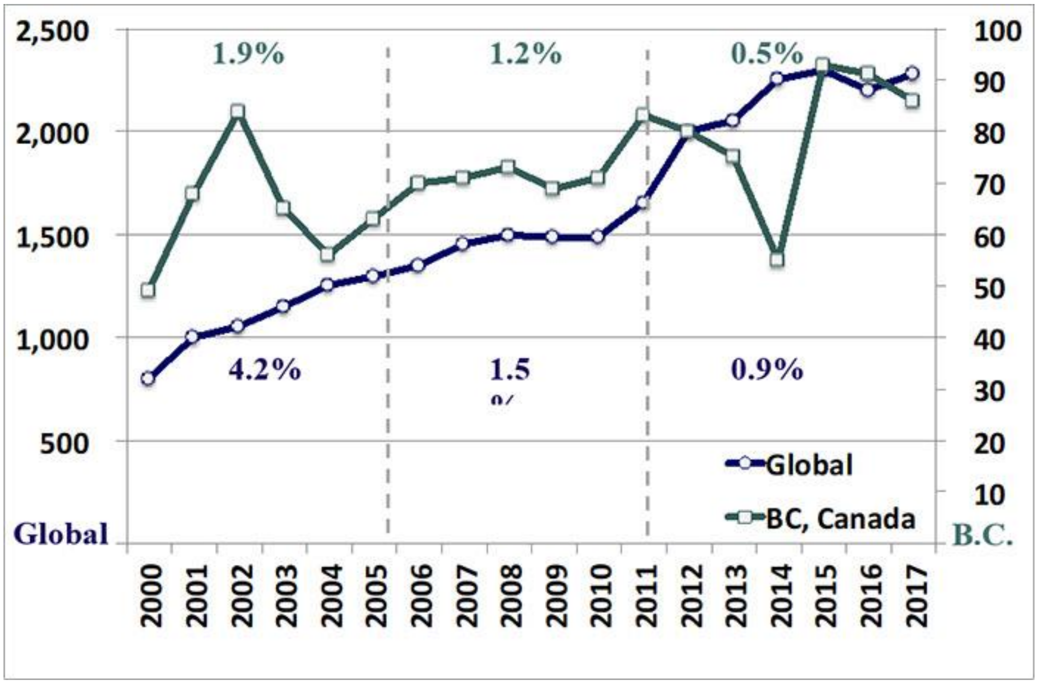

Figure 1: British Columbia and global salmon aquaculture production and growth rates from 2000 - 2017 (000s mt)

Canada's farmed salmon products compete in global commodity markets where prices fluctuate as much as 30% in a year according to supply and demand. Canadian producers must remain competitive and resilient under these market pressures.

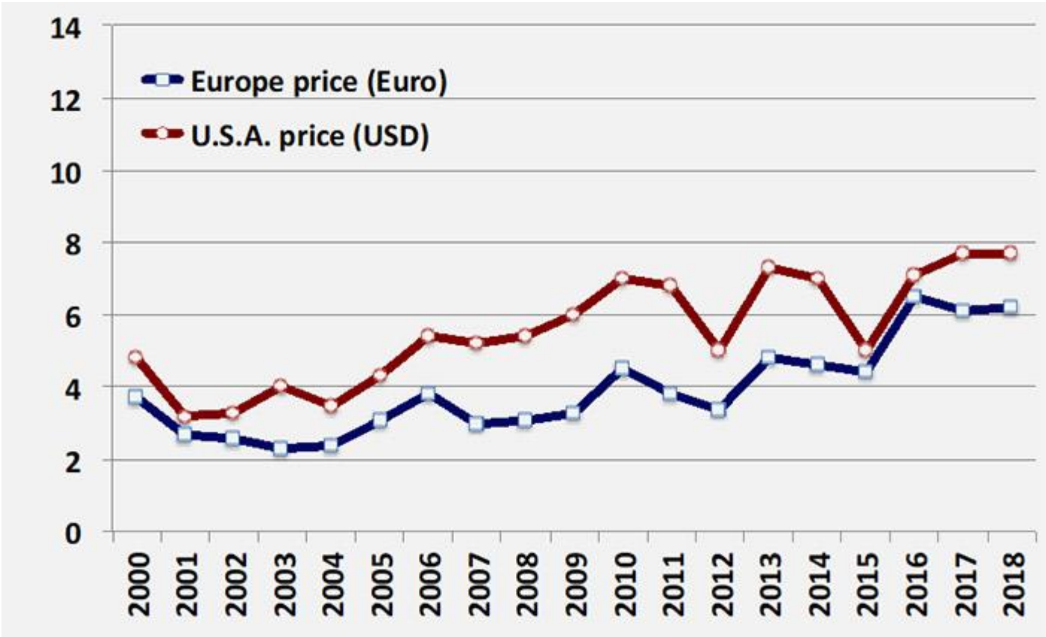

Figure 2: NASDAQ price indices per kg of farmed salmon in Europe and U.S.A., 2000 - 2018

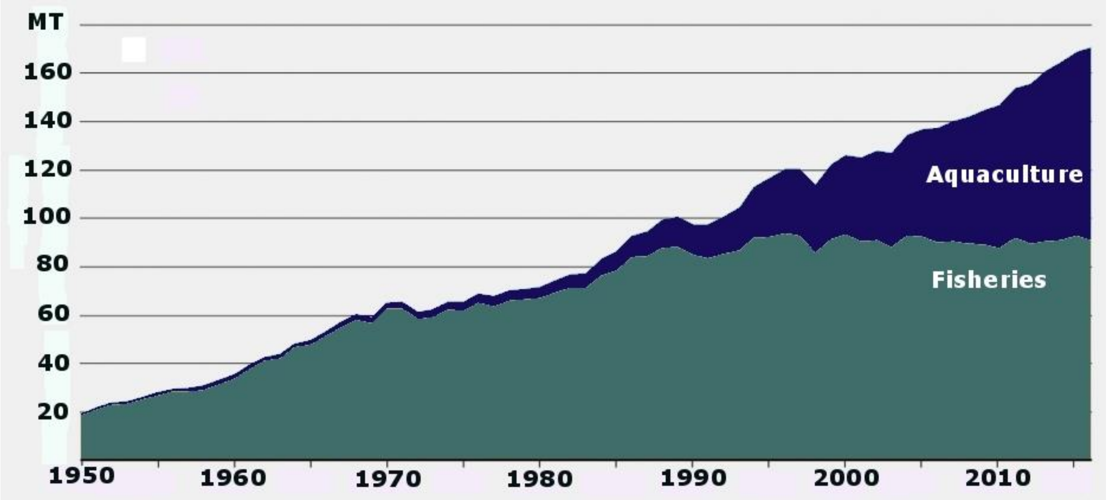

Figure 3: Global commercial fisheries and aquaculture production since 1950. Source: FAO, 2019.

This combination of pressures on salmon producers has spurred efforts to develop new technologies for salmon production that address the key issues noted above. The last ten years have seen major steps towards aquaculture production technologies that significantly reduce interactions between aquaculture and the natural environment. Closed-containment systems are of particular interest where, for example in land based systems, most water is continuously treated and re-used. Ocean-based closed containment (i.e., solid walled cages), and open-ocean (offshore) aquaculture systems are also being extensively researched. The use of these production technologies along with innovations such as sensor technologies and data analytics offer reduced environmental impacts for marine environments.

At this critical point in global salmon aquaculture development an assessment of alternative technologies for salmon aquaculture is necessary to advance sustainable economic growth in Canada. Fisheries and Oceans Canada (DFO) in partnership with the Province of British Columbia and Sustainable Development Technology Canada (SDTC) commissioned this study on the global state of salmon production technology with a focus on British Columbia's (B.C.) operating environment. This will support the aquaculture industry to consider alternative production systems that facilitates expansion of the industry to meet the strong growth and demand for sustainable seafood.

1.2 Indigenous communities

Indigenous communities have a key role to play as new aquaculture technologies develop in British Columbia. Indigenous communities are in an excellent position to participate in aquaculture growth due to their aquatic resources, rights, and access to suitable aquaculture sites. They are already engaged in every aspect of the salmon farming value chain from hatchery, grow-out, processing, and support services to distribution and marketing. They have also played a central role in new technology developments including the Kuterra land-based RAS project. National aquaculture socio-economic impact estimates indicate that about 10% of all economic activity in Canada is the result of Indigenous participation (GP, 2016). This percentage is higher in B.C. than other parts of Canada, and recent developments support further indigenous participation.

The Government of British Columbia adopted a policy in 2018 whereby, starting in 2022, the Province will grant tenures only to fish farm operators who have negotiated agreements with the First Nation(s) in whose territory they propose to operate. Indigenous communities are also highly engaged in aquaculture as investors, operating partners, and through a growing share of the aquaculture workforce. Indigenous communities are keenly interested in developing sustainable aquaculture production technologies.

1.3 Approach

Global scan
Canadian companies and researchers have participated in major technological developments including some of the first commercial land-based recirculating aquaculture systems (RAS), floating closed-containment systems (CCS), offshore production systems, and a range of sensors, remote operated vehicles, software and other system advancements. Most of these have been smaller isolated developments in Canada and they are not scaling up across the industry as rapidly as in other countries.

Major investments in leading systems at commercial scales are emerging in Norway, Denmark, Poland, China, and the U.S.A. among others. There are different reasons for advancement in each country that involve combinations of: the size of their aquaculture industry, size of consumer markets, constraints on marine netpen production, or supports for innovation in environmental, social, and economic performance. This assessment relies on a scan of global leaders to identify technologies that are emerging for commercial application and approaches that will move salmon technology forward.

Document review
As technology has advanced and the level of interest has risen dramatically, a great deal has been written about alternative production systems. Industry reports, government studies, academic research papers, conference proceedings, and popular press articles all provide a rich foundation of information for this assessment. As the developments are evolving rapidly it has also been helpful to obtain some of the latest information from the companies that are either developing these technologies or purchasing them.

Interviews
In order to fully appreciate the information and delve into key issues, including advantages and disadvantages of technologies, it is necessary to speak with many key informants. Private sector, public sector, academic, and non-government organization representatives have all helped to inform this assessment. This is particularly helpful with respect to

understanding how technologies that are being developed elsewhere should be considered for applicability in B.C.

Evolving technologies
It must be recognized that while this assessment can only reflect a point in time, aquaculture technologies are developing very rapidly. The relevance of similar assessments completed just five years ago is limited. Much of the information about the performance and capabilities of aquaculture systems quickly becomes outdated. The scale of commercial designs increase, capital costs per unit of salmon produced are dropping. The costs associated with new technologies are also dropping as demand increases and designs are standardized to produce modular "off the shelf" products. There are often annual improvements in the efficiency, reliability, and environmental performance of systems. This trend will continue over the next five years and beyond. This means that decision-making criteria such as environmental performance requirements can remain constant, but flexible, will allow for the ongoing evolution of systems and the arrival of other new technologies.

2. Scope of Assessment

2.1 Production systems considered

In January 2018, the B.C. Minister of Agriculture's Advisory Council on Finfish Aquaculture (MAACFA) Final Report made the following recommendation (5.2):

> *"Conduct a study examining the feasibility of utilizing closed containment technology in B.C. (land-based recirculating aquaculture systems, advanced net-pen systems, near-shore floating containment and off-shore farming systems) as (i) an alternative to ocean-based open net-pens and (ii) an option for expanding the current salmon farming production."*

This report builds on that recommendation, specifically by assessing the following four broad production systems:

- **Land-based recirculating aquaculture systems (RAS)** for market salmon;
- **Hybrid systems** combining land RAS production of post-smolts with marine grow-out to market size;
- **Floating closed-containment systems (CCS)** to produce market salmon; and
- **Offshore systems** involving open or closed containment systems.

There is also discussion of supporting technologies such as sensors, artificial intelligence, remote operated vehicles, and other developments that generally support advancements in all of these main production systems.

In order to consider the advantages and disadvantages that the four production technologies offer, the analysis relies on certain assumptions to make systems comparable.

- **Market size salmon** - All four systems are assumed to produce the same average size of market salmon (about 5kg).
- **Commercial scale production** - All systems must offer production capacity that is typically used by companies today (about 3,000 mt) and by arranging modular arrays and multiple sites the technology could be used to meet most or all of British Columbia's current volume outputs.
- **Steady-state analysis** - The analysis primarily focuses on a future steady state of operations for each technology. This is consistent with a number of the recent international studies on new technologies. In places, the construction and installation impacts are discussed to appreciate key differences between technologies.
- **Biomass limits for existing netpens** - The maximum biomass allowed for hybrid systems using marine netpens at current aquaculture sites is assumed to remain the same, although increases for semi-closed and offshore systems may be allowed based on meeting environmental performance requirements.

Before describing the new technologies in more detail, it is helpful to illustrate what environments they are being designed for (Figure below). Most of the environmental concerns relate to inshore sheltered marine ecosystems where wild salmon migration routes exist, are more concentrated and the opportunity for disease transfer are more pronounced. These inshore waters tend to be more shallow with weaker currents and lower rates of water exchange, so waste and effluent from aquaculture is more likely to build up and cause problems. The other technologies consider other location alternatives including land, inshore exposed sites or offshore sites. It has been easiest and cheapest to start developing aquaculture in sheltered inshore locations, but technology advancements now offer capabilities for operation in the other environments.

The most developed new technologies are designed for land and sheltered inshore environments. These new technologies have been operating at commercial scales for several years and "off the shelf" systems are more readily available. Inshore exposed systems and offshore systems are operating at commercial scales, but these have been deployed more recently and are expected to be refined in the next three to five years.

	Land-Based	Inshore - Sheltered	Inshore - Exposed	Offshore
Products:	Smolts Post-smolts Market salmon	Post-smolts Market salmon	Market salmon	Market salmon
Designs:	Recirc. Aqua. System	Semi-Closed Contained	Semi-Closed Contained	Semi-Closed Contained Open system
Readiness:	Developed	Developed	Developing	Developing

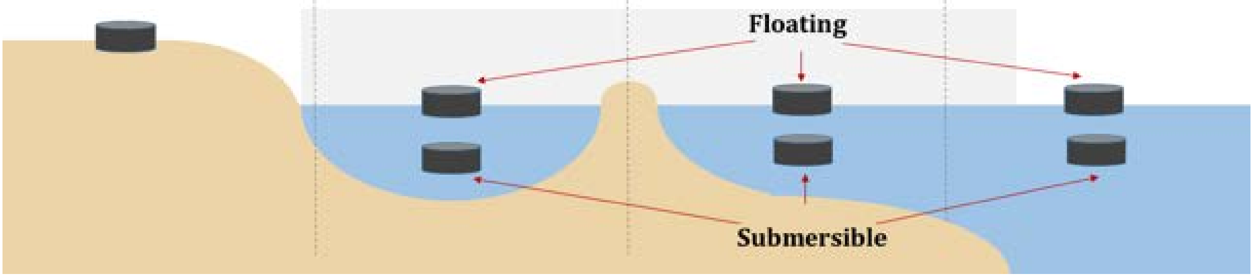

Figure 4: Conceptual diagram of reviewed technologies and their locations.

Currently about 98% of global salmon production comes from open netpen systems in sheltered and exposed in-shore environments (about 94% of B.C. total). The advancements this study focuses on are:

- **Closed containment** – using a barrier added to the containment system to stop transfer of diseases and pathogens, waste effluent, salmon escapes and other wildlife interactions. Water is pumped through the system and may be filtered before supply to the salmon, while waste is removed from outflows for processing on land.
- **Semi-closed containment** – using a barrier that does not remove all waste from system outflows, but reduces diseases such as sea lice.
- **Submersible** – systems may be open or closed with submersible capabilities to help avoid sea lice problems that occur near the surface, and to help access better growing conditions at greater depths (e.g. cooler water in summer). These also avoid storm damage and reduce salmon escapes.
- **Offshore systems** – are mostly open although some re-purposed marine vessels offer full containment that can be moved to offshore locations.

Many of the distinctions between new technologies are related to the grow-out stage of the cycle, and appreciating the implications of this will help to understand the assessment findings later in this report. The following stage sizes and growth periods are based on data from Kuterra research and insights provided by other salmon farming experts:

- **Smolts** are produced in freshwater land-based hatcheries regardless of the technologies that are used to bring salmon to market. Smoltification is when salmon change lifestages from being "parr" in freshwater to "smolts" adapted to saltwater, and this is induced in salmon hatcheries by controlling the amount of light salmon are given each day. This is now commonly done when the salmon reach about 100 to 150g after 8-10 months.
- **Larger smolts and post-smolts** are becoming more common and growers in B.C. are already expanding the use of land-based RAS to grow salmon larger before transferring them to sea. Globally the potential size ranges from 200g to 1kg or more before they are transferred to new technologies for on-growing, or remain in land based RAS to reach market size. Having said this, most of the focus is on larger smolts in the 200g to 500g range, with the aim of keeping the on-growing period to a year or less. The growth from 120g to 1 kg takes about 5-7 months. Since the optimal size for specific technologies and growth plans is still to be determined, there is a wide range of possibilities for this growth stage. This phase is most likely to be carried out in land-based RAS facilities, but may also be carried out by other technologies, especially floating CCS. For this report it is assumed to be carried out in land-based RAS, and grow out to market size is where different technologies are used.
- **Grow-out to market size** will take salmon from between 200g and 1kg to an average size in the range of 5kg to 6kg. The time needed to grow from 1kg to the 5-6kg range is about 9-12 months. The time frame will depend on the target harvest size, and starting at 250g will likely require the full 12 months while starting at 1kg will take closer to 9 months. Being able to keep the grow-out period short will be important for harvest rotations, and flexibility in the timing of transfer to new technologies. Also recognize that the salmon requires greater volumes of high quality water as it grows, and this has implications for the capital and operational costs of different technologies at this stage. For instance, a high proportion of closed containment systems investment is for larger tanks, pumps, and filtration systems needed to meet these grow-out needs, whereas marine systems largely rely on natural water flows and ecosystem services to provide these. In land-based systems the costs are borne by the producer, whereas in open marine systems the "costs" are external to the producer and may be borne by the public or other marine resource users.

2.2 Land-based RAS grow-out

Figure 5: Global Fish location in Poland producing market salmon since 2016

Land-based RAS involves growing salmon in tanks on land in closed buildings to maintain an environment that is highly controlled and secure. The water intake is treated with ultraviolet light or passed through special filters to prevent disease and contamination that could affect fish health. Upwards of 99% of the water is re-circulated on each cycle through the system. Waste material (e.g. faeces and excess feed) is removed from the water (e.g. drum filters), and depending on the contents of the material (e.g. salt) may be suitable for composting, supporting aquaponics (adjacent crop production), or producing energy in connected biodigesters. The water is then passed through bio-filters (bacteria living in sand or plastic media) to convert harmful ammonia generated by the fish into acceptable nitrate form. Aeration is used to drive out carbon dioxide generated by the fish, and oxygen is added to the water before re-circulation. Land-based recirculating aquaculture systems (RAS) have been used for decades in the production of salmon smolts (e.g. 75-100g). RAS designs have been used for an even longer period for producing a wide variety of other fish species. In the last five to ten years these systems have advanced to successfully produce market-size salmon (e.g. 4-6kg).

Some systems have produced up to 1,000 mt of salmon annually, but systems being constructed now tend to be 3,000 mt or more to achieve better financial returns. High capital costs have led to larger facilities being built to gain efficiencies of scale. The larger facilities employ modular designs to reduce risks associated with component failures or contamination events. The list in the table below is only a small selection of land-based RAS developments since there are now over 50 operating, under-construction, or approved, although not designed for market-size Atlantic salmon production.

Table 1: Examples of land-based RAS market salmon system capacities and developments as of 2019

Status	Company	Location	Capacity (mt)
7 years prod	Shandong Oriental	China	2,000
6 years prod	Danish Salmon	Demark	2,000
6 years prod	Atlantic Sapphire	Denmark	700
3 years prod	Global Fish/Pure Salmon	Poland	600+
4 years prod	Kuterra	Canada	370
4 years prod	Sustainable Blue	Canada	500
Construction	Atlantic Sapphire	USA	30,000+
Construction	Whole Oceans	USA	50,000
Construction	Nordic Aquafarms	USA	33,000+

Sources: UnderCurrentNews, 2019; FishFarmingExpert, 2019; company websites.

The initial proposed scale for the Atlantic Sapphire facility in Miami, Florida was 30,000 mt with a phased approach to reach 90,000 mt. The plan for 2030 was just increased to 220,000 mt in an announcement May 8, 2019. This level of production would supply more than half of the current salmon market in the U.S. The projected scale is still highly speculative since the site has not completed a production cycle at this time. Some operators have revised their capacity expectations (e.g. Danish Salmon) as they have not been able to reach initial estimates.

System requirements:

- **Coastal resources** - The versatility of land based RAS systems are facilitating salmon production in other countries with warmer climates including desert conditions (Evans, 2019). Still the need for freshwater and saltwater at temperatures suitable for salmon (e.g. 14 Deg C) means that coastal areas like those found in B.C. are ideal. A couple years may be needed to find the right combination of saltwater, well water, injection wells, transport networks, affordable land, power requirements, and local waste handling requirements. This time frame for siting has been the experience where land-based RAS has been planned and built elsewhere.
- **Low-carbon power** - The high rate of water pumping means that grid connected three-phase power is required, so remote sites where some marine netpen operations currently operate would not work. Electricity should be from a low-carbon source such as B.C. Hydro (about 90% hydroelectricity) given global commitments to reduce greenhouse gas emissions and expected increasing costs of fossil-fuel based power with carbon pricing.
- **Supply-chain** – This involves proximity to feed mills, fish health scientists, fish processors, equipment supply and maintenance companies, and distribution to consumer markets including excellent connections by road and air. When proximity to consumer markets is cited as an advantage of land based RAS in the U.S., it is usually referring to transport costs from Europe, whereas B.C. products reach the U.S. west coast markets and others quickly and economically.

- **Trained workforce** – Producers will need trained workers, and there is currently a shortage globally. Closely tied to this is the need for training programs through universities and colleges in coordination with working land based RAS facilities to provide hands-on experience.
  – (Hobson, 2018; G. Robinson pers. comm., 2019)

Remaining challenges:

- **Fish quality** – Managing the system to avoid off-flavours is an on-going key topic for RAS producers.
- **Fish health** – Microbes and bacteria in particular bacteria are being studied in closed system components, salmon tissues, and under certain growing conditions. Other issues include microparasites and water compounds such as sulfides that can reach toxic levels. Control measures including water intake and recirculation filters, construction materials, anti-fouling agents, ozone treatment, and fish waste management are all important areas of research.
- **Broodstock development** – This will focus on gender advantages, triploidy, late maturation, tolerance to high stocking density and low oxygen.
- **Large tank design** – There is ongoing research to optimize water velocities, placement and design of nozzles, and other measures to achieve proper distribution of oxygenated water and collection of waste in larger tanks of different shapes. This is critical to scaling up facilities.
- **Energy efficiency** – Improvements in water pumping, filtration, lighting, heating and cooling, and other system components and functions will continue to gain efficiencies while maximizing fish welfare and performance.
- **Feed formulations** – New developments aim to meet sustainability criteria with alternatives to fish meal/oil ingredients that are suited to land based RAS needs including efficient waste collection. For these systems this must not hinder biofilter function or off-flavours.
- **Stocking densities** – This affects water flows in tanks, fish health and welfare, revenues, loads on recirculation system components.
- **Design and construction efficiency** – Given the high impact of capital costs on the viability of these systems, there will be continued efforts to find more cost-effective designs and construction techniques.
- **Financial risks** – The projected addition of global salmon production due to land based RAS and other technologies is expected to bring prices down as the tension between supply and demand is alleviated (Gibson, 2019). Depending on the severity of price drops, land based RAS profitability may be affected. This market risk, coupled with production risks, will drive efforts to reduce land based RAS costs and build a stable track record to satisfy investors and insurance companies.
  - (Summerfelt, 2018; Føre et al, 2018; CtrlAqua, 2018; Aspmark, 2018).

2.3 Hybrid systems with land-based and marine sites

Figure 6: Marine Harvest Canada facility, Dalrymple, B.C.

Land-based RAS technologies are being developed for use in combination with marine grow-out sites (i.e. hybrid approach). The hybrid approach involves producing post-smolts weighing from 250g to 1kg. The land-based portion provides better growing conditions and reduces early growth phase risks at sea. The shortened grow-out period reduces some environmental risks at marine sites and avoids the most costly portion of land-based systems in the grow-out phase. The grow-out stage in land-based RAS systems requires substantially more capacity that increases capital and operating costs. Current hybrid technology development is focused on finding the appropriate size of post-smolts for transfer to sea as a number of factors are considered in order to optimize the use of the land and marine production systems. Regardless, the aim is to have salmon in the marine environment for at most one year instead of the typical two years for full marine production. Grow-out could involve floating closed-containment in near-shore environments or offshore production technologies, but the near-term focus is on utilizing netpen technologies at nearshore marine sites. Some examples of netpen technology innovations that help address environmental issues include: automated feeding systems integrated with sensors and machine learning to reduce waste, replacement of antifouling chemicals by high pressure seawater cleaning of netpens, improved materials for nets to avoid escapes and increase water flow through the system, and use of underwater remote operated vehicles (ROV) and robots for a variety of tasks. Sea-lice are a particular focus with developments involving: sea lice vaccines, anti-sea lice skirts, "snorkel" nets that keep salmon below sea-lice in the water column while allowing salmon to reach the surface for air-intake, sea lice detection and monitoring of individual fish, cleaner fish, wellboats coupled with CleanTreat technologies that cleanse the water effluent after treatments, as well as ultrasound and resonator treatments (BCSFA, 2018). The table below is a small selection of global hybrid technology developments.

Table 2: Examples of hybrid land and marine system developments as of 2019

Salmon size	Company	Location	Capacity (mt)
150g+	Grieg	Adamselv, Norway	1,600
250g	Norway Royal Salmon	Hasvik, Norway	2,000
500g	Bakkafrost	Faroe Islands	7,000
650g	Mowi	Faroe Islands	1,000
500g	Leroy Seafood Group	Hordaland, Norway	4,000
700g	Salmones Magallanes	Chile	Expansion
150g	Mowi	B.C., Canada	1,000
300g	Cooke Aquaculture	NB, Canada	Planned

Sources: UnderCurrentNews, 2019; HatcheryInternational, 2019; company websites.

System requirements:

- **Land-based requirements –** This portion of the production cycle in hybrid systems has some requirements equivalent to those already discussed for land-based systems. Keep in mind production of post-smolts generally requires saltwater but not in the Faroe Islands, for example, so water intake and discharge requirements may lead to different facility locations (adjacent to the sea rather than inland) compared to some land-based RAS hatcheries that are using freshwater only. Locating adjacent to the sea and near grow-out sites will also be needed for optimal transfer of salmon.
- **Transfer to marine sites –** This will be similar to conventional transfers today, however stress of fish at larger sizes is being studied to optimize procedures. New larger vessels (not only for transfers) are being designed to service marine sites and coastal infrastructure must be developed to support these.
- **Marine requirements – H**ybrid post-smolt system requirements are similar to existing netpen requirements. Depending on the regulatory limits for biomass by site and/or bay area, availability of sufficient sites to rotate stocking of larger post-smolts will require new production planning, and this can be accommodated in B.C.

Research challenges:

Research challenges identified in the previous land-based RAS are applicable for the hybrid system, although less pronounced since the hybrid approach does not need to bring salmon to market size on land. Land-based RAS hatcheries are already very experienced in producing smolts of about 150g for marine net-pen grow-out today, so hybrid systems need to extend this in the range of 200g to 500g or more and successfully transfer these to sea. Grieg Seafood in Norway put 400g smolts to sea in 2018 and harvested 6kg average salmon after 11 months (F. Mathisen pers. comm., 2019). Some of the specific hybrid system challenges are as follows:

- **Transfers –** The transfer of fish from land to marine sites can cause stress to fish and research is focused on determining the best conditions (e.g. temperature, salinity, feeding, fish size, and genetics) as well as new handling systems for low-stress transfers.

- **Sea lice –** The use of marine netpens for grow-out will continue to require methods for addressing sea lice, although the sealice presence and outbreak risks are greatly reduced with larger post-smolts spending less time in the marine environment. Addressing sea lice is not only a requirement for operation of marine sites, but it helps avoid reduced harvest sizes and revenues. The cost of sea lice management may continue to climb as resistance, fish welfare, and treatment effects on the environment drive investigation of more expensive alternatives. The use of skirts (additional barriers outside netpens) and other measures will continue to evolve for better protection against sea lice and wildlife interactions.
- **Algal blooms –** (Heterosigma algae) may persist as a problem for open netpens. Although insurance can cover some loses, this ultimately comes at a cost to operators. Oxygenation and aeration diffusers for structured upwelling (also to prevent sea lice) are promising to be effective for algal blooms.
- **Other environmental impacts –** Wildlife interactions, escapes, waste effluent, and other environmental issues associated with marine netpen sites will continue to be a focus of research efforts.
  - (Aspmark, 2018; Bjorndal and Tusvik, 2017)

2.4 Floating closed-containment systems (CCS)

Floating closed-containment systems (CCS) offer some advantages of closed systems while retaining some benefits of growing in a marine environment. There are design variations with solid or flexible wall construction, and mechanisms for collection of waste materials. The main advantages of this system include collection of most feed and faeces waste, cost-effective use of surrounding waters, and barriers to: diseases, parasites, wildlife interactions, and escapes. The growth and survival of salmon using floating CCS has been superior to open netpen systems, and there have been no sea lice issues. These are more suitable to sheltered sites in lower energy environments, but some are capable of operating in more exposed locations.

Figure 7: Aquafarm Equipment Neptune 3 system.

Most systems are fixed, but mobile versions using new or retrofitted marine vessels also meet floating containment criteria. All systems involve pumping water from sufficient depths (e.g. 12m or deeper) to address sea lice, algae, temperature regulation and other requirements. In most operational systems, the smolts from land-based systems are transferred to the floating CCS system for post-smolt production (1-2kg), then grow-out to market-size occurs in open systems. However, some are now being used to grow salmon to full market size (e.g. Neptune system). Cermaq plans to bring a system into B.C. operations this year to produce 2kg post-smolts in a flexible wall system. The Hauge Aqua designed "egg" technology, purchased by Marine Harvest and granted development licences in Norway, may be stocked this year. It offers a surface cover for complete enclosure, water filtration system, water intake from depth to avoid sea lice, waste collection system, and a unique feeding system that improves food conversion.

The capacity of most systems ranges from about 225 to 1,000 mt per tank and these can be combined in arrays to produce larger volumes. The concepts involving rebuilt ships currently produce about 300 mt, but are poised to become much larger and may eventually exceed 4,500 mt. The assessment (later in this report) will focus on using these for market grow-out, but these are likely to be integrated with existing open netpen arrays as an intermediate step (i.e. post-smolt growth).

Table 3: Examples of floating CCS system capacities and developments as of 2019

Status	Company	Location	Capacity (mt)
5 years prod (PS)	Aquafarm Equipment	Norway	1,000+ per tank
7 years prod (MS)	AkvaFuture	Norway	1,000+ per tank
7 years prod (MS)	AgriMarine*	Canada	1,000+ per tank
4 years prod (PS)	Preline	Norway	300 per vessel
Testing (MS)	Hauge Aqua	Norway	1,000 per egg
Testing (MS)	Botngaard System	Norway	400
Testing (MS)	Seafarm Systems	Norway	1,000

*Sources: UnderCurrentNews, 2019; FishFarmingExpert, 2019; company websites. PS=Post-smolt production, MS=Market-size production * Steelhead salmon grown in a low energy freshwater site.*

System requirements:

- **Coastal resources -** These must be located in sheltered coastal areas with access to suitable saltwater environments (e.g. temperature, currents, water quality). There is somewhat greater flexibility in sites compared to open netpens since warmer locations can be accommodated by pumping cool water from below the tank and sites prone to algal blooms may still be acceptable. Some land may be needed for processing waste materials.
- **Power source – G**rid-connected three-phase power is needed, so remote sites where marine netpen operations currently run on diesel would not meet requirements. Electricity should be from a low-carbon source given global commitments to reduce greenhouse gas emissions.
- **Supply-chain and access -** Connection to feed (inputs) and consumer market (outputs) requires excellent connection by road and/or air.

Remaining challenges:

- **Waste disposal** – Technologies for separating waste from water outflows will continue to improve. Research will seek to increase the amount of solids captured, minimize the amount of dissolved nutrients (e.g. nitrogen and phosphorus), and develop ways of processing and utilizing the waste materials on land.
- **Water flow and tank size** – There is ongoing research to optimize pumping of water through tanks of different shapes and larger sizes. Current floating CCS tank designs tend to be smaller than industry would like for commercial operation so this challenge must be addressed.
- **Structural design** – Materials used to build floating CCS tanks will be explored for rigid and flexible options. The shape and size of tanks as well as walkways, platforms, and other functional components will develop.
- **Market-sized salmon** – There is more floating CCS experience with post-smolt production and market-size for other species, and efforts now focus on refining approaches for market-sized Atlantic salmon production. - (Føre et al, 2018).

2.5 Offshore systems

Offshore systems were tested in Canada in the late 1990s with the launch of Ocean Spar cages in New Brunswick and Norwegian designs deployed in B.C. (Ryan, 2004). Early designs did not sustain commercial production and many improvements have been made globally since. Producers in the Faroe Islands have been leaders in contending with harsh marine conditions, and Ireland producers moved further from the coast in response to strong local opposition to near-shore developments. In the last two years most attention has focused on Norway and China where innovation has rapidly accelerated in response to supportive policies.

There are diverse concepts for offshore salmon aquaculture that each have merits for meeting certain offshore applications. The variety of designs include open and semi-closed systems, floating and submersible options, as well as fixed and mobile systems. Although definitions of offshore environments are somewhat fluid, all designs are meant to operate in minimum water depths of 20 metres and minimum wave heights of 1 metre. In the B.C. context much deeper waters (100-200m) and higher waves (at least over 3m and often over 6m) will be common and systems must operate through extreme events. The design of the structure that contains salmon is central, but equally critical is the design and logistics for servicing the more remote sites. Some designs include living arrangements for staff, while others rely on full automation so that workers are not required for day-to-day operations. Transportation to and from the site and land-side infrastructure are important as the challenges are greater for offshore production.

Figure 8: Topleft SalMars Ocean Farm 1, top right MNH Aquatraz, middle Marine Harvest Egg, bottom left Nordlaks Havfarm 1, bottom right NRS/Aker ASA Arctic Farm (Source: Norwegian Fisheries Directorate, 2019).

The SalMars Ocean Farm 1 holds about 6,500 mt and may be doubled in size. Ocean Farm 1, is mid-way through its year-long trial period, and is reporting good growth rates and low mortality (FAO, 2019). The Nordlaks Havfarm 1 is likely to be the world's longest vessel at 430 metres and capacity for 10,000 mt of salmon. Ramsden (2019) reported that MOWI's application for development licences in Norway was approved for its offshore "Blue Revolution Centre" research station and two offshore production technology designs – the "egg" and the "donut" concepts. Today's designs differ greatly and after a few years of operational experience companies will settle on preferred options. Once that occurs many more could be built with the view that salmon aquaculture industry growth will capitalize on the abundance of space available.

Table 4: Examples of offshore system capacities and developments as of 2019

Status	Company	Location	Capacity (mt)
2 years oper	SalMar owned	Norway	6,500
1 year oper	Rizhao Wanzefeng Fisheries	China	1,000
<1 year oper	Midt-Norsk Havbruk owned	Norway	1,000
2019 start	De Maas design	China	3,750
2020 start	Norway Royal Salmon owned	Norway	3,000
2020 start	Nordlaks owned	Norway	10,000

Sources: UnderCurrentNews, 2019; FishFarmingExpert, 2019; company websites.

System requirements:

- **Offshore locations** – These must be free of conflicts with other marine users including marine transport, protected areas, fisheries, oil and gas, and other resource extraction developments. In many countries these can represent constraints, but coastal B.C. offers many options.
- **Water quality** – This requires suitable temperature profile and currents, while remaining free of contaminants and fish health threats.
- **Transport access** – Ideal sites are within 25 nautical miles with reliable year-round navigation between on-shore and off-shore infrastructure. Floating ice and major storms (e.g. hurricanes and typhoons) can be limitations in parts of some countries, but extensive areas off the B.C. coast are suitable.
- **Proximity** – Minimizing transport for supply-chain inputs (i.e. feed mills and aquaculture goods and services suppliers) and outputs (ie. processing and distribution to markets) is important.
  - (CEA, 2018)

Remaining challenges:

- **Autonomous systems** – This system must incorporate technologies to become less dependent on labour for feeding, monitoring, mortality collection, net cleaning and repair among other regular functions. Guidance, navigation, and control of remote operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) are the subjects of intense research for offshore aquaculture.
- **Remote power** – Research is focused on production systems that integrate solar, wind, wave or water current energy to power pumps, sensor, robotics, and submersible functions are needed to run autonomous offshore systems.
- **Monitoring and decision-support** – to maintain structure integrity and fish heath in the face of challenging conditions including storms. These must be robust and capable of assessing whole farm conditions to drive scheduling and performance of key operations.
- **Structure design** – Efforts are focused on flexible and rigid components that provide functionality and security at remote locations. This also involves alternate shapes that are less vulnerable to offshore conditions, and technologies that allow submersible systems to avoid storms and still meet fish health and performance requirements.
- **Vessel design** – Well-boats that carry live fish, feed supply vessels, and service boats for fish treatments and structure maintenance are all being purpose-built. These must meet more rigorous standards for safety and functionality to handle the wider range of environmental conditions while maintaining safety of structures and personnel. Research is examining the size and shape of vessels, connections (e.g. cranes, hoses, platforms) with offshore aquaculture structures, and dynamic positioning capabilities for vessels to hold their position relative to the structures. Some of this technology is adapted from marine transport, oil and gas, and other marine applications.

- **Safety** – must be met according to occupational health and safety laws, which are not necessarily developed for offshore aquaculture. For instance, the Atlantic Offshore Health and Safety Regulations are developed under the Canada Labour Code with a focus on oil and gas activities. These specify requirements for training and education of personnel, certification of systems and equipment, risk assessment plans, monitoring and controls, record-keeping, passenger transit, fall protection, diving safety, and other requirements must be devised for offshore aquaculture.
- **Fish health** – key factors in offshore environments must be better understood. Stocking, feeding, treatment of diseases and parasites must be designed for this environment involving stronger currents and larger waves.
- **Wildlife interactions** – Unlike near-shore environments where most aquaculture production experience exists today, the offshore environment has different marine mammals and predators and there is a need to understand how they will interact with these systems, especially as they become larger and more numerous.
- **Regulatory uncertainty** – Pilot testing will help regulators to understand and monitor these systems then develop appropriate regulatory frameworks. Key questions involve site ownership, who will grant approvals, the application process and requirements to be met.
  - (Exposed, 2018; Bjelland et al., 2015, Fard and Tedeschi, 2018; NRCan, 2018; Holmen et al., 2017)

2.6 Supportive technologies

There are a wide range of technologies with cross-cutting benefits for all four alternative production systems. These technologies are not formally assessed according to environmental, social, and economic criteria, but they are expected to improve performance across the board. Some of the most promising recent developments are described briefly in turn below and a few Canadian opportunities are highlighted.

Sensors and control systems – Traditional data collection from monitoring and diagnostics is all being digitalized and analyzed in real-time for timely management decisions. Temperature measures, carbon dioxide and dissolved oxygen readings, video recordings, signs of disease, stress indicators, and many other important data feedbacks from the growing environment are captured from growing sites and monitored at data centres. This allows quick recognition of issues and faster response times. “Big data” can also be used to determine trends, identify drivers of performance, support decision-making, and link biological measures with economic performance. Sensors, feed systems, and computers are being linked by wireless networks building the Internet of Things for aquaculture production. Some data is already available on mobile devices so managers can monitor from anywhere. Software to integrate systems and employ artificial intelligence is leading to automatic decision-making by advanced production systems. Many companies are contributing elements and some are developing packaged integrated solutions.

“Intelligent” farming – Sensors and data analysis are being combined to deliver individualized farming for fish. This can lead to precise feeding and treatments for each fish based on fish health and a suite of measurements. BioSort and Cermaq have combined efforts to develop iFarm that uses recognition of spot patterns and other morphological features to identify individual fish and track their health. For example, instead of treating all fish for sea lice, only the individuals that meet thresholds will be treated. This type of technology avoids over- and under-feeding each fish, and individual fish can be selected for harvest based on size and availability.

Feed innovation – Feed suppliers must continually develop products that meet the changing needs of new production systems. Feed formulations are designed for certain health benefits to address diseases, diets for extreme environmental conditions, and to include novel ingredients such as immunostimulants, antioxidants, or metabolic stimulants. Feeds are developed for increased efficiency (i.e. feed conversion), better quality control, and more sustainable supply chains. Canada's largest feed suppliers including Skretting (offices in Saint Andrew's, NB and Vancouver, B.C.), and Corey Aquafeeds (Fredericton, NB), remain at the forefront of feed research and they supply feed to clients all over the world.

Transport and logistics – Marine vessels and containers are increasingly specialized for new production systems. Advanced positioning systems and cranes are being developed in parallel with the needs of new vessels. Work-boats and well-boats are equipped with fish handling and treatment capabilities, and harvest ships are being developed with on-board processing so salmon are ready for market by the time they return to shore. Other vessels are being specially designed for exposed and offshore locations including the Arctic. The international firm AKVA group (satellite office in St. George, New Brunswick) is delivering a barge to Arctic Offshore Farming (Norway Royal Salmon) to use above the Polar Circle. It can operate in 7.5 metre waves and has 800 tonnes of feed capacity for supplying submersible production systems. Canada has a number of ship and boat building companies that have extensive experience customizing designs for specialized applications.

Nets and mooring – As production systems move to exposed and offshore environments there is a need for innovation in containment materials (e.g. steel, HPDE, Dynema, AquaGrid and other nets). These offer strength, rigidity, reduced risk of escapes, reduced antifouling and maintenance, and suitability for integrating monitoring systems. Mooring equipment may come in flexible and rigid forms and it is critical to reduce risks associated with metal fatigue and corrosion, as well as component failure that could lead to potential system failure. Companies are developing products made of lighter-weight materials, with increased lifespans, faster installation, and certification to international standards. Based in Campbell River, B.C., Poseidon OceanSystems is a supplier of these products and spends close to half of staff time on research and development, resulting in over a dozen product innovations and four (4) patents in recent years.

Robotics – Semi – to fully automatic robots as well as remote operated vehicles (ROVs) now perform a number of previously difficult and costly tasks. Inspection of nets and moorings for damage has traditionally been done by divers, but dive time and safety precautions make this a challenge. Cleaning and repair of nets and other components can be done by robots, along with sample collection and analysis from sediments below nets or inside containment structures.

Specialized broodstock – It is becoming more important to develop salmon with certain high performance characteristics for new systems. Key characteristics include gender, late maturation, tolerance to less oxygen, survival in high energy environments (e.g. offshore), among others. Canadian salmon producers, universities, Genome Canada (B.C. and Atlantic centres), and private research firms are engaged in these developments.

3. Sustainable Aquaculture Technology Criteria

3.1 Technology assessment

Innovation in aquaculture aims to improve upon the performance of current production systems and ultimately the success of farm operators. Innovations may improve private and public outcomes of salmon farming operations. Improvements in private outcomes include better designs that lead to lower capital or operating costs, and improvements that gain more revenue through higher quantity and quality of products. Improvements in public outcomes may result from system designs that reduce waste released to the environment, avoid impacts to other wild organisms, minimize energy usage and greenhouse gas emissions, and provide more social and economic benefits to society.

Each of the four production systems that are profiled in this report are assessed according to a suite of criteria grouped into environmental, social, and economic themes. The criteria are considered important to assess since these relate to the primary issues associated with salmon aquaculture production to date. There is no order of importance to the criteria, none is assigned more weight than another, and these are all considered priorities for new technologies to address. After the criteria are briefly described below, the strengths and weakness of the four production systems will be assessed in terms of these criteria.

The assessment is forward looking since these are relatively new production systems that have yet to be widely adopted. As for all outlooks on new technologies there is some uncertainty regarding their performance at large scales and over the long-term. Aspects of the four production technologies that are subject to greater uncertainty and risk will be noted. It must be recognized that there are numerous designs and aquaculture sites for each of the four production systems and these will all have somewhat different performance capabilities, so the assessment is broadly indicative of the expected performance of each production system. Finally, innovation is moving quickly on all four production technologies and this assessment only represents a point in time and this should be reviewed as substantial advancements occur.

3.2 Environmental criteria

There are several key environmental criteria that new technologies aim to meet. The following briefly explains the essence of each criterion so that the benefits of different system capabilities are clear. The first five environmental criteria relate to outputs of salmon production and the last three relate to inputs.

- **Marine escapes** – New technologies must avoid salmon escapes from production systems, including escapes during salmon transfer and transport activities. Escaped salmon potentially affect wild salmon populations by competing for food and habitat, and by impacting wild populations through interbreeding.
- **Salmon diseases** – Transfer of diseases and pathogens between farmed salmon and wild populations must be avoided. Sea lice is currently the main issue although others are a concern (e.g. piscine reovirus, amoebic gill disease), while potentially resistant and new diseases in the future are also important to avoid.
- **Waste effluent** – Ecosystem effects of salmon faeces and feed falling to the seafloor must be avoided. These waste deposits cause oxygen depletion in the water as it breaks down and this can both suppress desirable marine organisms and promote undesirable ones (e.g algal blooms). Some commercial fisheries are concerned that effluents can affect the habitat, survival, and productivity of fishery stocks. In land-based RAS systems any saltwater discharge must be be done carefully to protect freshwater and marine resources.
- **Chemical release** – Release of harmful chemicals and substances into the marine environment must be avoided. The concerns include anti-fouling agents used to keep cages clean, chemicals used in the treatment of diseases, and feed ingredients. As these disperse in the environment, they can negatively affect other organisms.
- **Wildlife interactions** – Interactions with marine predators (e.g. seals and sea lions seeking salmon for food) as well as seabirds must be avoided. Wildlife can affect the farm structures and even the farmed salmon, or they may be killed by operators following protocols to protect their farm structures and stocks.
- **Water usage** – Unsustainable use of water must be avoided. The withdrawal or return of wastewater to sensitive sources, especially involving limited freshwater supplies such as aquifers, can deplete valuable water resources over time.
- **Energy usage** – High energy intensity must be avoided, especially from carbon-based and non-renewable sources. Renewable energy sources and grid connected electricity from B.C. Hydro (90% hydroelectricity) are best. Atlantic salmon aquaculture requires energy for system construction, operation, and transport of products to and from the site. As efforts to combat climate change accelerate, the energy types and quantities used will be increasingly important considerations. Life-cycle analysis results capturing all aspects of construction, operation, and delivery to market (i.e. egg to plate) are the best basis for comparing production technologies.

3.3 Social criteria

Long-standing tensions between salmon aquaculture producers and other interested groups are essential to resolve. Meeting environmental and economic criteria is part of resolving conflicts, but social criteria extend beyond this. Focusing on local, global, and consumer perspectives, the assessment highlights how the use of new technologies can help build support and trust in salmon aquaculture production.

- **Local support** – Local people in B.C. concerned about salmon aquaculture include: Indigenous people, other residents near production sites (permanent or seasonal), commercial fishers, recreational fishers, tourism operators, aquaculture employees, and local businesses that benefit from economic development. Local support will generally grow for new technologies that are *trusted* to deliver the benefits of aquaculture while minimizing the negative impacts. Understanding, engagement, partnership, and transparency in use of new technologies will enhance trust.
- **Global support** – Environmental non-government organisations (ENGOs) may have a local presence, but are often working more broadly to improve aquaculture operations nationally and internationally. Closely tied to this are third-party sustainable certifications for aquaculture products such as the: Aquaculture Stewardship Council farmed salmon certification, Global Aquaculture Alliance best aquaculture practices program, Monterey Bay Aquarium Seafood Watch program, and the Canadian General Standards Board organic aquaculture standard. These certifications help the other social objectives (i.e. local support and consumer support), as the support of ENGOs can also.
- **Consumer support** – B.C. producers ship to over 70 countries, however principal markets are in the U.S. and Canada. Many consumers are price sensitive and not necessarily aware of conventional salmon production issues. Eco-labelling can alert retailers and consumers to choices available, but these have had mixed results (Roheim et al., 2011; Rudd et al., 2011; Hallstein and Villas-Boas, 2013). As production grows using alternative technologies it may be important for access to certain markets including retailers, food service chains, or countries. Consumer perspectives will also evolve as more production from alternative technologies comes online and these products are no longer limited.

3.4 Economic criteria

New aquaculture technologies will change the economics of salmon production and this has implications for both aquaculture participants and the general public. Aquaculture participants including private companies, indigenous communities, lending institutions, insurance companies, and government will be concerned with financial performance. Local and regional communities, all three levels of government, and the general public will be more concerned with broader economic impacts beyond the interests of aquaculture participants.

- **Profitability –** New technologies must be profitable or they will not be (widely) adopted. Profitability is signaled by investor support of new technologies, and ultimately by successful operations that produce profits over several years.
- **Capital cost** – Capital costs will shape how quickly new facilities can be built and expanded. Capital costs are also a factor in financial risk (more below).
- **Operational cost –** Operational costs will affect long-run financial performance and ability to compete with other technologies and producers in the market.

- **Financial risk** – Financial risk will shape the speed and scale of technology adoption. The amount of experience and demonstrated operation of each technology at commercial scale will affect its speed of adoption as well as the profitability expected by investors (i.e. risk adjusted rate of return). Some risks can be mitigated with increased capital costs (e.g. back-up systems, sensors and alarms), or with operational costs (e.g. insurance), while other risks relate to market fluctuations and other factors that can't be controlled easily.
- **Supply chain** – The availability of the necessary supply-chain to support new technologies must be considered in the B.C. context. This includes technology suppliers, construction expertise, operational expertise, system inputs such as feed, energy, fish health testing, processing, marketing and distribution capacity.
- **Economy** – There is a public interest to maximize economic benefits in terms of jobs, incomes, community economic development, and tax revenues to governments. New technologies change the quantity and nature of economic benefits depending on system requirements, location, and potential to grow in a competitive global marketplace for salmon products. This report refers to full-time equivalent jobs unless otherwise indicated.
- **Expansion** – Each technology offers different opportunities for expansion of production in B.C. and for export of goods and services to other countries.

4. New Technology Assessment

4.1 Introduction

The strengths, weaknesses, and uncertainties for the four production technologies are assessed according to the environmental, social, and economic criteria in the tables below. More detail regarding the assessments for each criterion follows the tables.

Table 5: Environmental strengths, weaknesses, and uncertainties for the four new production technologies

Land RAS	Hybrid system	Floating CCS	Offshore system
Marine escapes			
• No risk, the system is contained on land.	• No risk during land-RAS stage • Some risk at sea and during transfers, but reduced time at sea and better transfer timing is helpful	• Low risk due to solid containment, and some risk during fish transfer to/from land	• Some risk due to open containment, but built for harsh conditions • Some risk during fish transfer to/from land • Uncertainties need more research
Wild salmon disease			
• No risk, the system is contained on land.	• No risk during land-RAS stage • Some risk at sea, but time at sea is reduced and salmon are larger and healthier	• Low risk due to solid containment, but still some risk as water filtration will not eliminate all concerns	• Some risks, but submerging capability avoids sea lice, and sites may be located away from salmon migration routes
Waste effluent			
• Waste can be composted, used in aquaponics, or to generate energy • Salt content can be a challenge	• Land-RAS waste can be composted, used in aquaponics, or to generate energy • Most waste is released to sea in grow-out, but some capture possible	• Low waste release with collection system and processing on land, but some dissolved nutrients (e.g. nitrogen, phosphorus) released	• Waste is released to sea • Location offshore in deeper high current waters will be better than inshore sites
Chemical release			
• Very low to no release outside the system • Chemicals are used for bacteria, gill diseases, and pH control	• Very low to no release from land-RAS phase • Marine phase releases chemicals to sea, but reduced use due to larger salmon	• Improved fish health will reduce chemical use, but as for waste effluent some will be released to sea	• Improved health will reduce chemical use, but released to sea • Anti-fouling agents on large metal structures are a concern, but this requires research
Wildlife interactions			

• No risk, the system is contained on land	• No risk for land-RAS phase • Some risk for marine phase, but may be improved with longer fallow periods	• Solid wall containment will eliminate risks • Mooring lines and structures may pose some risk to marine mammals	• Some risks with open containment, but integrity is expected to be very good • Mooring lines and structures may pose some risk to marine mammals • These topics require more research
Water use			
• Very low use in 99.5% recirculation systems • Use of aquifers by very large facilities is a concern	• Very low use for land-RAS phase since not used for grow-out • Marine phase only uses seawater flowing through	• The system only uses seawater flowing through, no limited freshwater resources	• The system only uses seawater flowing through, no limited freshwater resources
Energy use and GHGs			
• High energy use in system construction and operation • Grid electricity in BC has low carbon intensity • Location can minimize transport costs for feed to site and products to market	• Medium energy in grid connected land RAS facility since not used for grow-out • Low energy use in marine phase, but petroleum products may be used for boats and feed systems • Transport to/from marine sites adds to energy use	• Medium energy use in system construction and operation • Grid electricity in BC has low carbon intensity, but some sites may not connect to grid • Transport to/from marine sites adds to energy use	• High energy use in system construction • Medium energy in operation, and petroleum products likely needed for remote operation • Transport to/from marine sites adds to energy use • Research needed on these topics

Overall, all four production technologies offer improvements over conventional aquaculture production. There is no system with the best performance across all environmental criteria. Research is needed to complete more reliable assessments of performance expected for floating closed-containment and offshore systems.

Similarly, for social criteria in the next table, each of the four production technologies will improve local, global, and consumer support. Keep in mind that support is not homogenous or unanimous in each group, for example some consumers may support a particular new technology while others oppose it. The assessment aims to capture the general direction of support and what are the key factors to consider.

Table 6: Social strengths, weaknesses, and uncertainties for the four new production technologies

Land RAS	Hybrid system	Floating CCS	Offshore system
Local support			
• Environmental strengths will earn support, but very large facilities using sensitive water resources will likely raise concerns • Economic aspects may be a concern with fewer jobs, but market access and growth potential will build support	• Environmental performance of land-RAS phase will build support, but marine phase will still be a concern • Economic performance will support local jobs, but marine concerns hampering growth may dampen local support	• Environmental performance will build support, but use of marine sites may still be a concern • Economic performance will support local jobs, while market access and growth potential will attract support	• Avoiding near-shore spatial conflicts will gain local support • Jobs will remain in coastal areas, but there may be fewer with increased automation • Growth potential will build support
Global support			
• Seafood labelling will likely support this system as a “best choice”	• Seafood labelling will likely support this system as a “good alternative” since this already applies to B.C. farmed salmon	• Seafood labelling does not cover this technology for salmon, but it should garner a “good alternative” rating or better	• Seafood labelling does not cover this technology for salmon, but it may earn a “good alternative” rating
Consumer support			
• Premium prices today are an indication of consumer support • Moves to land-RAS in key markets may mean this system is needed for access • Product quality and fish welfare may be a concern • Higher cost may be a challenge to sell into price sensitive markets	• Products will not be distinguished from conventional netpen salmon • Establishment of land-RAS in key markets may limit market access for products of this system • Product quality and cost is very good, but there may be some concerns with marine contaminants	• Products will be distinguished from those produced by open netpen systems • Product quality and fish welfare will be considered good • Higher cost may be a challenge to sell into price sensitive markets	• Products may be distinguished from those produced by near-shore open netpen systems • Product quality and fish welfare will be considered good, but there may be some concerns with marine contaminants • Research is needed to address uncertainties

Table 7: Economic strengths, weaknesses, and uncertainties for the four new production technologies

Land RAS	Hybrid system	Floating CCS	Offshore system
Profitability			
• Large investments mainly by new entrants to farming are expanding this technology at large commercial scale • A couple years of commercial operations are needed to confirm profitability	• Large investments mainly by existing salmon farming companies indicate this is a profitable technology at large commercial scale	• Some investments by existing farming companies indicate this is a technology of interest at large commercial scale • A few years of commercial operations are needed to confirm profitability	• Investments mainly by new entrants to farming indicate this is a technology of interest at large commercial scale • A few years of commercial operations are needed to confirm profitability
Capital cost			
• Cost of 5,000 mt facility is \$10 to \$14 per kg of capacity • Cost of 10,000 mt facility is \$7 to \$10 per kg of capacity	• Land-RAS for post-smolt costs much less than for grow-out • Marine phase for grow-out uses very low cost netpen systems in use now	• Cost of \$5 to \$15 per kg of capacity indicates wide range of designs being evaluated	• Cost of 5,000 mt or more facility is about \$20 per kg of capacity • Other designs exist, but costs are uncertain
Operational cost			
• Cost for operations is \$5 to \$6 per kg of annual salmon produced • New sites are locating near markets to reduce transport costs	• Land-RAS for post-smolt costs much less than for grow-out • Marine phase uses very low cost netpen systems in use now • \$3.5 to \$4.5 cost per kg needs research	• Cost is lower than land-RAS, but higher than hybrid system • \$4.5 to \$5.5 cost per kg needs research	• Cost may be one of the lowest amongst new technologies given high degree of automation and use of ecosystem services • Research is needed
Financial risk			
• Biological risks are mortality, high maturation rates, and growth challenges • Market risks are price drops, currency changes, lost price premiums as land-RAS market share increases	• Biological risks are very low since this is an extension of existing technologies • Market risks are those normally associated with salmon aquaculture	• Biological risks are mortality due to system failure • Market risks are price drops, currency changes, lost price premiums as new technology market share increases	• Biological risks are mortality due to high energy environment, system or component failure, growth challenges • Market risks are those normally associated with salmon aquaculture
Supply-chain			

• Feed, fish health, processing, distribution and sales are in BC, but are being developed where new sites are emerging elsewhere • There are limited expertise in BC for construction and operation of land-RAS systems so training and imports are needed	• All elements of the supply chain exist in Canada, although advanced RAS design and expertise draws from other countries • Some additional training are required to expand land-RAS workforce	• All elements of the supply chain exist in Canada including design and operational expertise • Some additional training are required to expand use of this technology	• Most elements of the supply chain exist in Canada, although offshore design and construction expertise draws from other countries • Specialized boats and training for offshore is needed • Research is needed to determine all requirements
Economy			
• Fewer jobs per mt of salmon (26 – 30 direct jobs per 1,000 mt of salmon) and not necessarily in rural areas • High average salaries due to more technical expertise required	• This system keeps most jobs (35 – 40 direct jobs per 1,000 mt of salmon) and largely where they are located now • Some more advanced expertise jobs will command higher salaries	• This system keeps most jobs (35 – 40 direct jobs per 1,000 mt of salmon) and largely where they are located now • Some more advanced expertise jobs will command higher salaries	• There are fewer jobs due to higher amount of system automation • Jobs are still located in rural areas • Some more advanced expertise jobs will command higher salaries
Expansion			
• Several large facilities could double BC salmon production • Site selection takes time to meet requirements, especially discharge permits	• Some expansion can occur at existing marine sites, but grow-out concerns must be addressed for new sites to be allocated	• Some expansion of production can occur by replacing netpens at existing marine sites, and allocation of new sites should be more acceptable due to environmental performance	• BC offers extensive opportunities for expansion once the technology is proven through test sites

The combination of readiness for commercial development, likelihood of being profitable, economic impacts, and opportunity for expansion are what determines the financial and economic benefits expected from new technologies. Overall, land-based RAS and hybrid systems are ready for commercial application in B.C., while the others still need five to ten years. Land-RAS though less financially proven offers greater opportunity for expansion as long as this occurs in B.C. The hybrid system is likely more profitable and anchored in B.C., but expansion may meet challenges.

4.2 Land-based RAS grow-out

The following assessment considers the best available land RAS technology, application in B.C., and facilities being built in different B.C. locations.

Environmental criteria:

- **Marine escapes** – Zero
- **Wild salmon disease impacts** – Zero
- **Waste effluent** – There are no concerns since this is handled on land with acceptable disposal in more advanced designs including: composting, soil amendments for aquaponics (plant production) linked to the facility, or energy generation using biodigesters. Discharge of saltwater must be done carefully to avoid contamination of freshwater or marine resources, and land-based RAS offers the best potential waste management of the new technologies.
- **Wildlife interactions** - Zero
- **Chemical release** – Infection with pathogenic or opportunistic microbes is the main concern in these systems, but standard anti-microbial treatments are avoided since they harm the beneficial bacteria used in the bio-filters (denitrifying bacteria). These systems employ some antibiotics for bacteria, formalin for gill parasites, and alternatives such as low dose ozone.
- **Water usage** – This is minimal in state of the art re-circulation systems, in fact salmon facilities are already operational in desert environments. There is a caution regarding exceptionally large developments and sites with water limitations or sensitive environments (e.g. aquifers). Requirements for a depuration stage to deal with off-flavours before sale to market may also use more water than the rest of the production scale.
- **Energy usage** – This depends on system design and location. In general, these systems use more energy in construction and operation than other systems (Ayer and Tyedmers, 2009). This can be partially offset by generating up to 10% of operational energy requirements using biodigestion of waste material, and locating in proximity to both feed sources and consumer markets to reduce transportation energy. Use of solar panels, wind turbines, and low carbon electricity sources can alleviate climate change concerns.

Social criteria:

- **Local support** – Strong local support will be built on the system's ability to improve environmental performance across nearly all measures. Protection of wild salmon, addressing concerns in recreational and commercial fisheries, and avoiding other marine spatial conflicts will substantially address the opposition to salmon aquaculture. Depending on how land-based RAS is developed, local direct and indirect economic opportunities may be lost so coastal communities will raise concerns. There has been some local opposition to the recent large proposed facilities in the U.S. on the basis of water resource concerns or potential noise issues.

- **Global support –** Land-based RAS systems are expected to meet or exceed sustainability certification requirements. This is a strong indication that global support from environmental organizations will continue. Monterey Bay Aquarium's Seafood Watch™ lists "worldwide indoor recirculating salmon" grown salmon as their "Best Choice" (MBA, 2019).
- **Consumer support** – The acceptability of products from this system is expected to be high since premium prices have been captured in some markets. This does not imply that price premiums will continue, only that it reflects consumer support. The ability to avoid chemicals in feeds and system treatments will appeal to consumers. The assurance of clean water circulating through the system will be an important feature for consumers concerned about pollutants in the marine environment. There have been some historical issues with off-flavours, but these are addressed in modern designs. The issue of fish welfare may yield mixed consumer responses. On the one hand fish welfare is improved with optimal growing conditions and avoidance of potentially stressful treatments for sea lice and other ailments. On the other hand, high biomass density and aggressive fish behavior must be well-managed with transparency to consumers. Some consumers may perceive land-based facilities as an unnatural environment for raising fish and there will be a need for producers to address this.

Economic criteria:

- **Profitability** – Announcements of secured funding for numerous large-scale projects has proven that investors are ready to move this system forward even with relatively high risk. There is a concern that failures of these large projects to deliver on promises to investors could hamper the momentum that exists. Given the need to monitor the success in the next few years for the large systems being built, there is still some caution before declaring these are profitable.
- **Capital costs** – The capital costs have dropped substantially over the last ten years and are now in the range of $10 to $14 per kg of salmon capacity for systems with 5,000 mt capacity (Bjorndal and Tusvik, 2017). The largest proposed projects today (over 10,0000 mt) are in the $7 to $10 per kg range (AquaMaof, 2019). These figures do not account for production not always meeting capacity, so actual capital costs per kg of salmon produced will be important to confirm going forward. These capital costs include: site preparation, buildings, electrical, concrete work, RAS equipment, and other installations (excluding land). The time required for permitting is related to capital costs. Any complexity and delay of permitting and approvals is a deterrent to development of land-based RAS systems since financial capital is tied up longer. The locations where large projects are going forward took many years to meet all regulatory requirements. This ultimately represents a cost to operate, risk to investors, and challenge to achieve returns on projects.
- **Operational cost –** The operational costs are competitive with other systems, especially where optimal growing conditions and system advantages can reduce costs, and reduced transportation exists in ideal locations. The expected production costs per kg of salmon from land based RAS are now about $5 to $6. For B.C. the transport to the U.S. is economical, but shipping to Asian markets may be a competitive challenge with this system, especially as local Atlantic salmon production capacity in Asia is growing

rapidly. Taking into account production challenges such as growing salmon to full size and avoiding any system failures, the actual long-term operational cost will be confirmed going forward.

- **Financial risk –** Pathogen control, biosecurity, and system component failures are key concerns for investors as mortality incidents can be severe. High rates of early salmon maturation, poor feeding response to husbandry practices, and stocking density issues can also impact growth, quality, and ultimately revenues. Although recent financing success is a strong indicator that risks are being addressed in new systems, along with a considerable amount of research to advance the above noted concerns, this is ultimately confirmed through successful operations over a number of years. The current environment is favourable, with salmon prices above $9 CAD per kg over the last two years, but in 2011 and 2012 prices fell below $7 CAD per kg (22% lower). These systems must demonstrate financial resilience through price volatility, and also in a global production growth environment. As more land-based capacity develops along with other emerging technologies, a higher proportion of product will be able to meet high consumer expectations and this could erode any premiums that are possible.
- **Supply-chain –** Most of the supply-chain elements required for this system are available, but land-based RAS does not have the best supply-chain advantages amongst the four technologies considered. System-specific managers must be trained and the expertise for construction and maintenance are being primarily developed in Europe. As large-scale land-based systems are being developed particularly in the U.S., the advantages in B.C. are not sufficient to have already attracted large developments, and supply-chains will now be developing elsewhere.
- **Economy –** Advanced skills and expertise are required for most positions in RAS facilities so locations with excellent training and aquaculture industry presence are in a good position. Given the advanced labour requirements, the salaries and wages are attractive for salmon farm workers. However, the location of these systems is very flexible so coastal employment opportunities may be lost as production moves closer to consumer markets and distribution centres. There are also fewer jobs per tonne of salmon produced than most other alternative technologies. Land based RAS systems operating at commercial scale in B.C. are expected to generate about 26-30 direct jobs per 1,000 mt of capacity (CounterPoint, 2019). This is only a small decline compared to hybrid or floating CCS, and a bit more than anticipated for offshore systems. The nature of the jobs will be more technical and average salaries will be higher. The most significant consideration is where these jobs are located in B.C. or elsewhere.
- **Expansion –** Sites already selected for existing, under-construction, and proposed land-based RAS facilities around the world demonstrate the flexibility in siting this technology. Although there are many considerations for meeting system requirements and optimizing performance, British Columbia offers options for suitable sites. Based on the size of land parcels secured for recent large-scale farms in Maine and Florida, about 32,000 mt of salmon can be produced on about 20 hectares of land (50 acres). Subject to water source availability, all of the current farmed salmon production in B.C. could be accommodated in a combined space of about 60-hectares (150 acres). This does not mean it is a simple matter to identify the best location(s), and a couple years may be required for site selection considering the substantial investments involved.

4.3 Hybrid system

Assessing the performance of this system revolves around the salmon growth stage from about 100g to 500g where land-based RAS is used. Any environmental and financial risks associated with the fish at this stage in the marine environment are addressed by moving to land, and there are some additional benefits in the marine grow-out phase. The following assessment assumes the marine portion utilizes open netpens with some improvements and that the allowable biomass in netpens remains the same. Any other improvements to the marine phase involving closed, submersible, or offshore developments would further address a number of the marine risks.

Environmental criteria:

- **Marine escapes** – Escape risks are zero during the land-based phase so over the full life cycle there is a reduction, but not an elimination of risk. During the marine portion low escape risks are expected due to the shorter time at sea, more secure transfers from land to water, and added flexibility regarding when fish are in the marine environment. Transferring larger fish from land will require better vessels and equipment to secure the fish. Shortening the marine phase to one year or less creates flexibility in the timing of stocking and harvest so that adverse weather conditions can be avoided for transfers and growing periods. However, the risk of escape is not zero for the marine portion.
- **Wild salmon disease impacts** – Lower, but not eliminated, disease risk will result from reduced time in the marine environment and increased size of the fish. Sea lice treatments may only be needed once or not at all for the maximum one-year at sea. The shortened time at sea will prevent build-up of sea lice, and the larger fish will be less susceptible to sea lice and other diseases. There is also potential for longer fallow periods that allow disease cycles to be broken.
- **Waste effluent** – Since the land-based portion of the growth cycle is comparable to other systems there are no additional concerns. However, the open netpen system does discharge waste effluent to the marine environment and this will be for the most intensive part of the grow-out at the end of the cycle even though the grow-out period is shorter than for conventional aquaculture. Longer fallow periods will provide some benefits for seafloor recovery, and some waste capture is possible though at higher cost.
- **Chemical release** – Again the marine portion of cycle will be open to the marine environment. The expected reduction in sea lice treatments will reduce therapeutants and other treatment releases in marine waters.
- **Wildlife interactions** – Interactions with wildlife are eliminated for the land-based portion and the marine phase risk is reduced to the extent that the number of sites is reduced and fallow periods are prolonged.
- **Water use** – The length of time salmon will spend in land-based RAS facilities may be half of their life-cycle, but the water usage will be substantially less than half. Salmon growth up to 200g – 1kg needs much less water than salmon growing through the latter part of the cycle to market size (5-6kg). Very high re-use rates that do not depend on sensitive water sources (e.g. aquifers) will perform very well.

- **Energy use** – Similar to water usage, the energy usage for post-smolts in the land-based system is about 10-20% that of the energy required for producing market-sized salmon. The other energy consideration is the location of the land-based system relative to feed sources and consumer markets. In B.C. there will be local supplies of feed, but the primary markets are distant (U.S. and overseas). Land-based RAS for post-smolts in B.C. will offer partial location advantages (feed source) in terms of energy reductions. The energy intensity of the marine component is also low.

Social criteria:

- **Local support** – Although many marine site producers have favourable relations with local communities, this production system is expected to be more contentious than the other four technologies. Local support will improve somewhat based on system gains in environmental performance, but continued use of open netpens will not eliminate issues. Although it may be possible to reduce the overall number of sites so the least appropriate ones today can be abandoned, there will continue to be concerns. On the other hand, this system is most likely to maintain aquaculture employment where it currently exists so there will be corresponding favourable perspectives from coastal communities.
- **Global support –** Although not as environmentally attractive as land-based RAS systems for full on-growing, this system should yield enough improvements to meet most environmental certifications for salmon aquaculture in marine environments. Monterey Bay Aquarium's Seafood Watch™ lists Aquaculture Stewardship Council (ASC) certified Atlantic salmon as a "Good Alternative", and B.C. marine netpen Atlantic salmon are also listed as "Good Alternative" (MBA, 2019). Hybrid systems in B.C. upholding ASC requirements would be viewed favourably.
- **Consumer support** – The salmon products from this system will not likely be distinguished from current netpen products, unless this facilitates third-party certifications the consumer will see on products. As many companies shift to new technologies, high environmental performance will become a consumer expectation rather than a feature. Any potential consumer concerns with salmon spending their full life-cycle in land-based facilities would be largely addressed in this system by spending their last year at sea.

Economic criteria:

- **Profitability** – The financial attractiveness and feasibility is evident as companies are already adopting this system. Grieg Seafood in Norway, for example, started moving toward this system in 2007 and is aiming for 300g average smolt in 2019. The increased costs of sea-lice treatments, faster salmon growth and operational advantages of a hybrid system make it an easier financial decision, but it has taken some time to transition.
- **Capital cost** – This is lower than for full grow-out in land-based RAS or in offshore systems. Permitting and approvals are relatively straight-forward for conversion of existing marine sites to hybrid ones, however there may be challenges getting approval for any new sites in B.C. (more below).

- **Operational cost** – The operational costs are competitive since it aims for the best combination of land-based and marine-based systems. Costs in the range of $3.5 to $4.5 per kg are likely, but research is needed.
- **Financial risk** – This approach is already operating at commercial scales and is being closely considered in Canada. There is no concern whether it can be done reliably, only a question of how far it can go in terms of maximizing the land-based phase and minimizing the marine phase.
- **Supply-chain** – The supply-chain considerations are associated with the land-based facilities including suppliers of the RAS systems and components, and suppliers of feed. Canada would currently seek the most advanced system designs and components from other countries. Recent expansions of RAS for larger smolts (e.g. MOWI) have used European suppliers, but have customized the system in Canada. Feed production is already well established in Canada so there those economic benefits are captured locally.
- **Economy** – Advanced skills and expertise are required for most positions in RAS facilities so locations with excellent training and existing industry presence such as B.C. will be in a good position. Coupling land RAS with a marine stage keeps production locally in the province. More jobs per tonne of salmon will be retained than with full RAS systems. Many jobs will have advanced labour requirements so the salaries and wages will be attractive for salmon farm workers. Hybrid systems operating at commercial scale in B.C. are expected to generate about 35-40 direct jobs per 1,000 mt of capacity (CounterPoint, 2019; MNP, 2015; Bjorndal and Tusvik, 2017). This is similar to floating CS and more than the other two systems. There will be a mix of more technical jobs associated with post-smolt production and current jobs for grow-out operations so average salaries will be slightly higher. These jobs are more likely to remain where they are currently located in B.C. since proximity to grow-out sites will remain important.
- **Expansion** – Some growth of production could occur as a result of using this approach at existing marine sites, however there are anticipated limits to expansion due to on-going concerns with the marine component. Even though some growth is possible, this technology offers the least opportunity for expansion in B.C. amongst the four technologies considered. The improvements in the marine phase with open netpens will not likely be sufficient to lift the constraints on near-shore site availability in B.C. Social licence to expand will require more substantial changes to the marine phase involving other technologies such as near-shore submersible and floating containment systems, or offshore system development.

4.4 Floating closed-containment systems (CCS)

Environmental criteria:

It is important to mention that floating CCS systems are more often considered for post-smolt growth in conjunction with marine netpen grow-out to market size and this technology may have greater opportunity for this type of application. However, the purpose of this assessment is to assess potential for producing market-sized salmon, and there are some preliminary efforts to develop this at commercial scale. It is also important to note that the assessment is focused on solid-wall systems, as opposed to flexible-wall systems that are more limited in where they can be located (sheltered, low energy marine environments).

- **Marine escapes** – Escape risks are low given the full containment structures, but not zero as for land RAS systems. There have been historical escape events from floating CCS systems due to design issues that led to structural failures during storm events. The most recent designs have made many improvements to lower this risk, but the potential for escapes still exists, especially during transfer of salmon to and from the site.
- **Salmon diseases** – These systems will significantly reduce build-up of sea lice, but other disease transfer is possible as untreated water is pumped through the system. Because water is taken from deep under the structure, operators have reported excellent results with no sea lice. Filtering and treatment of outflows may be possible in future, but these are not developed at economical stages yet.
- **Waste effluent** – Considering the most advanced designs that include waste collection and processing on land, the waste effluent is significantly reduced compared to open systems. However, some dissolved nutrients and waste particles are not captured, and there are difficulties processing saltwater waste materials.
- **Chemical release** – Reduction in sea lice and other diseases minimizes or eliminates therapeutants and treatments that are released in marine waters.
- **Wildlife interactions** – Interactions with wildlife are certainly reduced by solid-wall tanks, but not eliminated altogether. Mooring lines and anchoring systems could be a concern for marine mammals, but this requires further research with implementation of these systems.
- **Water use** – Since the water usage is not derived from limited sources (e.g. aquifers), this issue is not associated with these systems.
- **Energy use** – Energy usage is greater than for open netpens, but lower than land-based RAS requirements. Grid connected electricity is best, but not always possible so self-sufficiency with solar and wind energy is being developed to avoid the need for diesel generators. Some energy is used in the service and supply activities to the structure, but this is not substantial over the production cycle or life of the system.

Social criteria:

- **Local support** – Improved local support will rest on the system's ability to improve environmental performance across most measures. The continued use of near-shore sites will not eliminate marine spatial conflicts. These systems have performed well in areas that are prone to algal blooms, so their use maintains flexibility for selection of suitable sites. This system is most likely to maintain aquaculture employment where it currently exists, so local economies will benefit and coastal communities may view this favourably.
- **Global support – T**his system offers a number of environmental performance improvements over open systems and should achieve environmental certifications for salmon aquaculture. However, Monterey Bay Aquarium's Seafood Watch™ list does not

include recommendations specific to floating CCS (MBA, 2019). More experience with these systems over the next few years will confirm the level of support.

- **Consumer support** – Market-sized salmon produced from this system will garner consumer support. There should be a positive consumer association with salmon growing at sea while employing technology with a small footprint to address many of the marine impacts and wild salmon concerns. Certifications and product labels (i.e. global support) will help convey this to consumers.

Economic criteria:

- **Profitability** – Signs of financial attractiveness and feasibility are emerging as companies are investing in this technology. A few years ago this would have been considered a more expensive system, but the increased costs of sea lice treatments coupled with operational advantages of this approach are making it an easier financial decision. There is not yet a surge in development, but proof of commercial viability will grow in the next few years.
- **Capital cost** – Capital costs range from \$5 - \$15 per kg of salmon capacity and this wide range reflects the variety of designs still being considered. There are fewer opportunities to gain economies of scale and bring unit capital costs down as for large offshore or land based technologies.
- **Operational cost** – The operational costs are lower than for land-based RAS, but higher than for hybrid systems. Costs in the range of \$4.5 to \$5.5 are likely, but research s needed.
- **Financial risk** – The financial risks associated with system component failures or market fluctuations are much lower than for land-based RAS or offshore systems.
- **Supply-chain** – Canadian companies offer some designs, but use of systems and components from other countries is likely since leading manufacturers are positioned in Europe. Feed production is already well established in Canada so this is one reason for Canada's economy to perform well with this system.
- **Economy** – Some labour requirements will include more advanced technical training and higher salaries, but the existing worforce can adapt easily to this system. The number of jobs required is comparable to current industry operations and the use of B.C. marine sites will keep employment in coastal communities. More jobs per tonne of salmon will be retained than with full RAS systems. Floating CCS operating at commercial scale in B.C. is expected to generate about 30-35 direct jobs per 1,000 mt of capacity (modified from MNP, 2015). This is closely related to netpen labour requirements with more technical management and maintenance offset by reduced treatment and fish health activities. The mix of occupations will command slightly higher average salaries. These jobs are likely to remain where they are currently located in B.C. since marine grow-out sites will be important.
- **Expansion** – Some growth of production could occur as a result of this approach, however there are anticipated limits to marine expansion. The environmental performance advantages, once fully proven, would offer suitability in a wider range of sheltered in-shore environments, but the issue of marine spatial conflicts will place limits on this. As the systems become more robust for submersible and in-shore exposed applications, there will be more expansion potential.

4.5 Offshore

The following focuses on offshore designs that are open with submersible capabilities. These are common characteristics among contending designs that should be examined for performance, recognizing that closed systems will offer even greater environmental advantages as they develop in the medium-term. These systems are all likely to be stocked with post-smolts 200g or larger produced from land-based RAS systems. Larger fish are preferred for stocking to increase survival for offshore systems in stronger currents with higher wave energy.

Environmental criteria:

- **Marine escapes** – The risk of escapes is relatively low since these systems are built for very harsh conditions, and the integrity of the containment system for salmon is extremely high. However, there have been issues with earlier systems and it will be important for next generation systems to demonstrate their integrity.
- **Salmon diseases** – These are likely to be open systems so diseases will not be contained, however they offer some advantages for protection of wild salmon from sea lice and potentially other diseases. They will be located away from migratory routes of wild salmon. They will have capabilities such as submergibility to grow salmon below the water depths where sea lice are prevalent. There will be more space offshore to separate growing sites so the transfer of sea lice between sites and resulting build-up will be lowered. Uncertainties about interactions with wild salmon require further research.
- **Waste effluent** – These large systems will produce high amounts of waste given the large number of fish stocked in each structure, however the main waste effluent issues are related to near-shore sites where water depths are much shallower and currents are weaker. Impacts to benthic communities are likely to be minimal offshore given the ability of currents to disperse waste more widely. As long as these materials are biodegradable and do not pose threats to marine life (i.e. better feeds), the amounts accumulating on the seafloor are not expected to trigger problems. Some waste collection is possible, but this raises costs.
- **Chemical release** – Disease pressures including sea lice are expected to be lower therefore use of treatments and therapeutant will be minimized. Where anti-fouling agents (e.g. copper) are used, there is some concern that these will be more common on large metal structures, and once they fall to the seafloor it would be a challenge to recover this in deep waters.
- **Wildlife interactions** – As for open netpens today, wildlife interactions will occur. This is the subject of research to determine what wildlife interactions will be most important at offshore locations, and how these will be handled in terms of preventive measures as well as maintenance of system integrity. Since these systems will be built with stronger materials for security and integrity, this should improve performance. As for floating CCS, offshore system use of mooring lines and anchoring systems could be a concern for

marine mammals, but this requires further research with implementation of these systems.

- **Water use** – This is not considered an issue for offshore systems.
- **Energy use** – There are three main energy requirements to consider namely: the offshore structure construction and operation, the transport of personnel and goods to and from the offshore structure, and proximity to feed sources and consumer markets. These large structures will require substantial energy in construction, although not as much as land-based RAS, and the operational energy requirements will be low since currents will move water through the system. Leading designs are optimizing construction materials to reduce environmental and economic costs, while offering the strength required for offshore environments. Renewable energy such as solar panels and wind turbines can be incorporated into offshore systems, and this will be used to run automatic feed systems, remote operated vehicles, cage movements (rotation or up and down in the water column). Transport of goods and personnel to and from the offshore sites will add to energy requirements, although the frequency of ship movements will be relatively low. Developing these off the coast of B.C. will have the advantage of short distances to existing feed supplies, but still remain distant from major consumer markets.

Social criteria:

- **Local support** – Moving offshore will avoid many marine spatial conflicts and address many environmental concerns, so this should gain strong local support. This system has the ability to maintain aquaculture employment in coastal communities, although the labour requirements are reduced for both the land and offshore phases compared to the hybrid alternative.
- **Global support –** Although not as environmentally attractive as land-based RAS systems for full on-growing, this system should yield enough improvements to meet or exceed the highest environmental certifications. Research over the next few years observing commercial scale systems will confirm the level of support. Monterey Bay Aquarium's Seafood Watch™ list does not include recommendations specific to offshore systems (MBA, 2019).
- **Consumer support** – Through sustainable seafood certifications consumers will recognize that this system addresses many environmental concerns. It will be appealing as a system that produces salmon at sea, as long as appropriate regulatory measures are in place and the offshore areas are perceived as clean environments for food production.

Economic criteria:

- **Profitability** – The financial attractiveness and feasibility is least evident with this system as the largest investments in offshore salmon aquaculture have only begun recently and most are concentrated in China. The drivers for investment in China are different, but some salmon production companies in Europe are deploying offshore systems also. The next 3 to five years will confirm profitability at commercial scales.

- **Capital cost** – This is lower than for full grow-out in land-based RAS, but not as low as hybrid systems. Approvals and permitting processes have not been fully elaborated so this extends the wait for investors. Once this is resolved, the long-run prospect for permits and approvals will be superior to other alternatives owing to the space available and uniformity of offshore locations. The unit capital cost of 5-6,000 mt capacity offshore systems in Norway and China are just over $20 per kg of growing capacity. Annual capital maintenance and depreciation is about 2% of capital costs. The increased costs relate to the large solid structures required to maintain the system in high energy environments. Larger vessels for deployment and servicing are costly, anchoring systems, and advanced automation and controls add to the total. The amount of fish produced in the system is the partially offsetting factor that keeps unit capital costs in a reasonable range (CEA, 2018), but further research is required since multiple designs could emerge successfully.
- **Operational cost** – The operational costs are very competitive since these systems make the best use of automation and natural resources. A 10-15% additional cost compared to conventional netpens is expected in the near-term for offshore systems (CEA, 2018). This is definitely competitive with land-based RAS and floating closed containment system costs, and has the potential to be more economical in the long-run. Feeding and salmon growth is currently not as efficient in offshore environments, insurance costs, and transport to and from shore are key drivers of operational costs.
- **Financial risk** – There is currently a financial risk given this is the newest technology among the alternatives and several years of operation are needed to confirm its reliability. Since there is a relatively high capital investment, it is important to demonstrate that the system is resilient to component failures and market fluctuations (e.g. lower salmon prices).
- **Supply-chain** – Leading offshore system designers and manufacturers are located outside of Canada, however it is possible to bring modules to Canada for domestic assembly and customization. As for other systems, the other primary input is feed supply, which is well-established in Canada.
- **Economy** – Personnel are sometimes needed on the offshore structures, and in transport of goods to and from offshore sites. These positions are fewer than for hybrid systems, but they require advanced skills and expertise and are therefore well-paying. Since this system will utilize B.C. marine waters, this approach will help to retain local jobs. Offshore systems operating at commercial scale in B.C. are challenging to assess, however the high degree of automation and challenging environment point to lower labour demands. There will still be all of the supply-chain, processing and sales activities so direct jobs are estimated in the 20-25 range. This is the lowest among the four systems. The jobs will all be technically demanding so average salaries will be high. The main consideration is that the location of jobs, especially those tied to the offshore site activities will shift in B.C.
- **Expansion** – There are very few limitations to expansion of offshore systems therefore substantial growth could proceed once this technology is fully proven. B.C. offers extensive offshore waters that are suitable for salmon production. It will likely be a decade before significant commercial operation occurs in Canada or the U.S. (CEA, 2018).

5. Development pathway in B.C.

5.1 Introduction

The technologies assessed in this report are operating at large scale, but at different stages of maturity so they are not all ready for commercial application in Canada. Land based RAS and hybrid systems are ready and B.C. is in a position to advance these now, but floating CCS and offshore systems need to be deployed in Canada for a few years before declaring their readiness. The latter two still deserve substantial investment as they offer great potential for grow-out in the marine environment.

The traditional driver for global industry to innovate is for competitive reasons; to reduce costs of production and secure markets. As global demand grows for protein sources and seafood in particular, investment will flow into salmon aquaculture. Production technologies will compete to become the leading modes of supply, and sustainability is increasingly a critical part of attracting investors.

The objective for B.C. is to ensure that investments lead to development of the technologies offering the best combination of environmental, social, and economic performance. Building on existing programs and supports for aquaculture in Canada, this section examines key approaches and measures that target preferred technologies, recognizing that leveraging market forces can help to achieve desired outcomes. Each technology may have different needs so a combination of measures is needed.

5.2 Legislation and policy

Clear and effective legislation and policy has been a pre-cursor in other countries to the development of new technologies. Clarity and stability allows investors to leverage capital, which is essential to profitable businesses and investment in innovation. There have been a number of statements in Canada regarding the need for regulatory clarity and consolidation in the form of an Aquaculture Act (Senate, 2015), and continued work on this initiative will be helpful as long as it maintains a view to the promising technologies reviewed here. In discussions with experts working on each of these technologies there was at least one key area of uncertainty with regard to policy and regulations for each system.

- **Land-based RAS** – The provincial waste discharging permits under the B.C. Environmental Management Act, both for water and solid wastes are topics of uncertainty for land-based system developers. Traditional farms can only use composted aquaculture waste materials as fertilizer for crops if these meet content requirements, in particular low salt levels. This can require costly advanced processing and/or limit potential uses of waste materials. Further, ambiguity exists with the discharge of water effluent with a lack of clear standards where RAS effluent is concerned. Clear and unambiguous permitting criteria are needed to attract developers of this technology. Determining acceptable water intake requirements is another area of uncertainty and it is recognized that this can be site-specific and system-specific, also that it involves testing and assessment processes that take time. One solution is to identify suitable sites that are (pre-) approved based on limits to resource use and waste discharge, then a streamlined approval process for the site will facilitate investment. This could be accessible to multiple companies at a given site providing synergies between producers and cost-efficiencies.

- **Hybrid systems** – These are already being closely considered in B.C. so the regulatory path is more straight-forward, although some questions remain regarding the maximums for biomass stocking and use of marine grow-out sites. The shift to larger fish with shorter grow-out periods allows for different site planning including the number of sites, stocking rotation, and fallow periods. Use of the DEPOMOD aquaculture waste deposition modelling software by DFO and routine sampling under the Aquaculture Activity Regulations must confirm that benthic impacts continue to be within acceptable limits.
- **Floating CCS** – Current legislation and policy is mainly designed for open netpen systems and ensuring that these do not exceed the carrying capacity of the marine environment or interfere with wild salmon populations. Floating CCS largely addresses these issues and should therefore be considered for increased biomass stocking. This would improve financial performance by providing greater returns (i.e. revenue from fish produced each cycle) to support more rapid payback of the capital investment, and improved operational returns, and would ultimately encourage more rapid adoption of this technology. Like land-based RAS, identification of a site for further development of the technology at commercial scale would be helpful by streamlining the approval process.
- **Offshore** – The greatest regulatory and policy uncertainty accompanies offshore aquaculture systems. There is a recognition that the next offshore development projects in Canada may actually help to shape regulatory and policy formation. Implementing a small number of projects will allow for observation and evaluation before opening the offshore to widespread aquaculture development. A developmental licence tailored to the specifics of a prospective technology will be sufficient initially, then more comprehensive requirements can be devised for general development in the future. The Norway Government (2017) has recognized that offshore aquaculture technology is developing so rapidly that flexible rather than prescriptive regulations should be adopted to support ongoing innovation.
- **Hybrid and floating CCS systems –** Marine salmon farms in B.C. are already regulated for sea lice management through their conditions of licence. However, the requirements are not designed to incentivize adoption of new technology. In Norway's "traffic light" system, very low thresholds are set for sea lice and if these are met then marine sites (individually or within a bay) are allowed to increase their biomass stocking, and if not met then biomass stocking is reduced along with other measures. The traffic light system involves maximum average counts specific to sea lice gender, stage of salmon development, time of year, location of salmon

farm, and other factors that are the basis for treatment thresholds, reporting requirements. This motivates producers to adopt the best approaches to minimize or eliminate sea lice, which include technologies in this report.

5.3 Nurturing innovation

Researchers and innovators are needed in B.C. to accompany and guide the development of new technologies. Once new technologies accelerate and the scale of production from these systems increases, researchers and innovators will be more attracted to the sector in B.C. This means there is a positive feedback loop involving innovators and development of new technologies, where growth of one promotes growth of the other. In order to accelerate this, a number of suggestions emerged in the preparation of this report.

- **Intra-industry tech transfer** – In the effort to develop new technologies research and development is often carefully guarded, even if it will eventually be publicly released (e.g. academia), and it can remain entirely confidential in the private sector (e.g. patent development). In some cases this will continue, but the pitfall is that developers working independently without sharing information are likely to duplicate research efforts and repeat mistakes that others have made. The solution is to facilitate and coordinate information sharing. Norway recently tied information sharing and collaboration requirements to the issuing of developmental licences for new technologies. The licences in Norway normally come at a high price and new production capacity is very difficult to obtain, so companies are encouraged to meet the additional requirements. As a result, Norway is the undisputed world leader in fostering an innovation culture that combines government, academia, and the private sector.
- **Inter-industry tech transfer** – There are a number of industries such as aquaculture, fisheries, offshore energy, and marine transport that face common challenges in the marine environment. The need for information sharing and collaboration on technology development between these industries has been recognized in Norway's Ocean Strategy, in particular the opportunity for more established industries (e.g. offshore energy) to share technology for new developments, especially in aquaculture (Norway Government, 2017).
- **Resource mapping and marine spatial planning** – The need to identify marine areas (inshore sheltered, near-shore semi-exposed, and offshore) for appropriate development of aquaculture technologies must be integrated with other industries using marine resources (e.g. offshore energy, transport, tourism, national defence). Again, the Norway Ocean Strategy recognizes a role for the national government to coordinate and deliver integrated digital mapping (i.e. GIS) that contains the key data for businesses and regulators and is distributed so this can be used extensively.
- **Training** – The need to ramp up labour force training and research capacity goes along with efforts to grow new production systems. Several key informants indicated that initiatives will be required to shift the existing aquaculture workforce to more technical positions, and new workers need to be prepared and recruited to avoid a shortage as new technologies surge ahead. The solution is to coordinate

college, university, and private sector training programs with an emphasis on the needs of new production systems. There is a particular gap in proficiency with the "supportive technologies" outlined in this report so companies that develop sensors, software, robotics, and other components may need to be engaged in the development of training programs. Building a critical mass of trained and informed people from different perspectives will stimulate innovation as more human capital can be turned to improving performance.

- **Conferences** – There are a number of forums for leaders in new technologies to share information about recent developments, but these often focus on international projects and topics. B.C. actors will continue to learn from international developments, but the concerted push for new technology development in B.C. requires regular opportunities for discussion of local interests. Meetings provide opportunities unlike information sharing through reports and research results, since it is important for all audiences to participate, ask questions, and contribute to the research and development agenda. The solution is to facilitate an annual meeting in B.C. initially, which could move to other parts of the country as new technologies are deployed.
- **Transparency** – When separate research efforts lead to different perspectives on key issues it can be difficult to resolve competing claims. This leads to confusion and lack of trust on the part of non-technical actors and the general public. The solution is to support public posting of consolidated scientific information in order to help build social support for new aquaculture technologies. Sharing research "dead ends" is just as important as "big discoveries" so that everyone appreciates what has been investigated. As new technologies are deployed, the monitoring and performance data should be readily available for open discussion.

5.4 Financial incentives

The hybrid technology is already being closely considered in B.C., and the other technologies are advancing moreso in other countries. This suggests there is a gap with respect to the other three that requires an incentive or support in order to advance. Financial incentives are used by governments to serve a public interest (e.g. job creation, environmental protection) in two key situations: 1) when jurisdictions compete to attract businesses that are flexible with respect to location, and 2) when businesses want to establish in a particular location, but there is a financial challenge to overcome.

The hybrid system and land-based RAS system are the most capital intensive and likely candidates for financial incentives. The hybrid system and floating CCS technology cannot be located anywhere in the world, since the combined location criteria for each technology must be met and B.C. offers a number of options. Land-based RAS for grow-out and offshore systems are more flexible in location around the world so B.C. competes with others for investment to establish this technology. The following examines financial incentives in the context of developing these systems in B.C.

- **Development licence fee reduction** – In some countries open netpen aquaculture licences are subject to substantial fees, and licences are exchanged between companies at high market prices. Norway instituted fees for licences in 2002 and licences for the standard 780 mt of capacity have recently sold for over $10 million (DNB, 2017). The "development licence"s for projects that meet innovation criteria have been granted for free initially and, after a period, may be convertible to normal licences for about $1 million (90% below value). Over 50 companies have applied for these licences, since they represent the only substantial opportunity for growth. The savings are meant to offset investment costs in alternative technologies. This means access to production is very difficult to obtain even when it is available at all. In order to support new technologies, these licences can be issued for reduced fees (marine) or no fee at all (e.g. land-based RAS in Norway). This requires a high fee to be established in the first place, then preferred technologies can be charged less in order to help advance more sustainable technologies.
- **Local benefits** – Following on the last topic regarding high fees established in Norway, there has been a recognition that benefits should be enhanced for communities that host marine aquaculture production. Norway's Ocean Strategy reported that large portions of the proceeds from new aquaculture licences are now allocated to the local municipalities.
- **Payroll rebates** – These can be helpful, although the labour requirements for new technologies tend to be less than for conventional aquaculture so this is not a strong incentive for investment in new tehnologies.
- **Research and development funding and credits** – Canada has a suite of programs to support research and innovation costs, but there is always a need to target these toward priorities in a coordinated fashion. Identifying technology expansion in aquaculture as a top priority will help to align federal, provincial and regional programs. The various agencies should be aware of projects that are being moved forward so that support can be maximized or duplication avoided as appropriate. The European Union's (EU) Horizon 2020 funding program, for example, provided €1.94 (Euros) for Aquafarm Equipment to develop their Neptune floating CCS technology at commercial scale. This is part of the EU Blue Growth Strategy to sustainably develop more resources from the oceans without compromising benefits for future generations. In Norway there is a small levy on all salmon exports and collected in a fund to be matched 50-50 with industry investments in research and development.
- **Accelerated capital depreciation** – each of the technologies in this report are more capital intensive than conventional netpen aquaculture and could benefit from accelerated depreciation of capital. The attraction of this tool is that the benefit flows when it is most needed up front, and then diminishes over time as the balance sheet improves. The Canada Revenue Agency (CRA, 2019) does offer an Accelerated Investment Incentive program for manufacturing and processing equipment (e.g. fish processing) and for clean energy equipment that may be part of new salmon production systems.
- **Joint ventures** – Government can play a role by working with private companies and other organizations to invest in new technology. This has already been done with Namgis' Kuterra project in order to demonstrate the feasibility of land-based RAS

for grow out at small commercial scale. This model is an option for other technologies going forward.

- **Guaranteed loans** – This is the last form of incentive profiled since it was not raised as a key tool for attracting investment. Unlike five to ten years ago, there is a current belief that investors have sufficient capital to initiate projects. This is clearly occurring with land-based RAS in the U.S., China, and Europe. This form of financial incentive nevertheless helps, but the other incentives and removal of barriers or gaps is likely more important. Furthermore, the companies building land RAS for grow out and offshore systems are now offering to lease their systems. This removes the need to raise capital, and risks associated with the system remain with the supplier. This reduces the need to tap loans from government and builds trust in the system, so salmon producers can just focus on growing their products for market. Guaranteed loans could play a role in pilot projects, smaller independent commercial developments, and Indigenous community involvement in new technology deployment.

5.5 Biomass allocation

The introduction to this report highlighted the slowing pace of salmon aquaculture production globally and in B.C. despite the strong and growing demand for products. This tension creates a strong desire from aquaculture companies to gain access to biomass allocations. As mentioned above, Norway has ensured that access to biomass is tied to use of the best performing technologies.

- **New biomass allocations** – The main principle is that growth should be allowed only when and where the environmental footprint is acceptable. This approach involves new biomass allocations being contingent on investment in new technologies. New allocations can include renewal of existing sites once leases expire, incremental additions of biomass at existing sites, or approval of altogether new sites. Decisions to support additional allocations at existing sites or new sites are rule-based and have more stringent environmental performance requirements (e.g. minimized sea lice levels, no escapes, and reduced benthic impacts). This drives the need to invest in new technologies including land-based RAS for grow-out, floating CCS, or offshore systems. This provides companies with enhanced financial means (revenues and profits from production) and incentives to invest in the new technologies.
- **Trading in open netpen sites** – Norway has issued biomass allocations under new technologies with the requirement for companies to retire an existing open netpen site. This effectively transitions the industry to new technologies over time.
- **Hybrid system as stepping stone** – Although performance of this system is not as high as the other alternatives considered, this one does put in place elements that can support development of the other technologies in the future. Expansion of land-based RAS facilities for post-smolt production can be pushed to larger sizes and full market size in the future. Post-smolts will be needed for floating CCS and offshore systems once they are established. The advancements in marine vessels and other system components also necessary for other systems. The hybrid system may be a

way to get known infrastructure in place, while less developed technologies are finalized for commercial adoption.

5.6 Innovation support in Canada

A number of people interviewed in Canada remarked that "we already know how to support innovation; the approach in other sectors just needs to be applied to aquaculture". The issues and concerns with conventional aquaculture may have prevented a concerted effort to support research, expansion, and export development. With a clear aim to support innovative technologies that address key issues and move beyond current approaches, perhaps a renewed coordination of programs will be possible.

Available elsewhere in Canada:
Growers in B.C. indicate that Atlantic Canada aquaculture companies have access to more support programs that are not available in B.C. or are not designed for the aquaculture sector.

- **The Atlantic Innovation Fund** (AIF) encourages partnerships among private sector firms, co-operatives, universities, colleges and other research institutions to develop and commercialize new or improved products and services.
- **Innovative Communities Fund** (ICF) invests in strategic projects that build the economies of Atlantic Canada's communities, including projects that enhance environmental performance.
- **The Atlantic Trade and Investment Growth Strategy** is a homegrown, historic, and groundbreaking initiative — the first of its kind in Canada — to grow export and boost foreign investment in the region.
- **Atlantic Canada Opportunities Agency (ACOA)** - has supported land-based RAS developments, as well as adoption of new systems or system components for netpen aquaculture.

Focused on other sectors in Canada:
B.C. operators also note that federal programs and those particularly developed for agriculture do not offer similar access for the aquaculture sector, or in some cases aquaculture is ineligible for funding. There are indications from Agriculture Agri-Food Canada that the lack of funding eligibility for aquaculture stems from the view that aquaculture does not fit clearly in the department's mandate. This is a prime example of the need for aquaculture to have it's own clear legislation and policy rather than falling between the lines of different departments.

- **The Innovation, Science and Economic Development Portfolio** - Seventeen federal departments and agencies contribute and are uniquely positioned to further the government's goal of building a knowledge-based economy in all regions of Canada and to advance the government's jobs and growth agenda. This should be re-examined for strengthening the focus and support for advancing the four new production technologies in this report.

- **Agricultural Clean Technology Program** - Funding for projects led by provincial and territorial governments for clean technology research, development, demonstration, commercialization and adoption projects in Canada's agriculture and agri-food sectors ($25 million over three years).
- **AgriInnovate Program** - This program provides repayable contributions for projects that aim to accelerate the demonstration, commercialization and/or adoption of innovative products, technologies, processes or services that increase agri-sector competitiveness and sustainability.
- **AgriScience Program** - The program aims to accelerate the pace of innovation by providing funding and support for pre-commercial science activities and cutting-edge research that benefits the agriculture and agri-food sector and Canadians.
- **Indigenous Agriculture and Food Systems Initiative** - Supports Indigenous communities and entrepreneurs who are ready to launch agriculture and food systems projects and others who want to build their capacity to participate in the Canadian agriculture and agri-food sector.
- **Canadian Agricultural Partnership (formerly Growing Forward)** - For over 15 years, the Canadian government has used agriculture policy frameworks to enhance the competitiveness of agriculture and agri-food companies. The Canadian Agricultural Partnership is a five-year, $3 billion federal-provincial-territorial investment in the agriculture, agri-food and agri-based products sector that began in April 2018, and a five-year $5 million B.C. Agrifood and Seafood Market Development Program is available. This is a small portion of the program and does not support technology development, while land-based parts of the program do.

Need increase support and priority for aquaculture:
Aquaculture is eligible for funding under some federal programs, but these are not targeted solely to the aquaculture sector or are insufficient to support the potential growth of new technologies. These programs need to be prioritized toward aquaculture by allocating more funding and/or creating categories that are focused on new production system technologies in aquaculture.

- **DFO Fisheries and Aquaculture Clean Technology Adoption Program –** This four-year program offers $20 million with a sunset in 2021. Funding up to 75% of eligible project costs is for integration of market-ready clean technologies in day-to-day operations. This has supported integration of RAS technology at a B.C. salmon farm, as well as installation of a biodigester to process fish waste and produce power for a land-based facility;
- **DFO Atlantic Fisheries Fund –** This program, only in Atlantic Canada, offers $295M with a sunset in 2024, and supports research and development of new innovations, bringing them to market, and the creation of partnerships and networks that help innovation in the sector;
- **DFO B.C. Seafood Innovation and Restoration Fund –** Funding is available in B.C. only, for $142.8 million with a sunset in 2024. Current priorities include projects that meet criteria for improved sustainability of the aquaculture industry to ensure the protection and conservation of marine ecosystems and wild fish populations;

- **Sustainable Development Technologies Canada (SDTC):** SDTC funds research and development of new technologies across a range of economic sectors. Funding has already supported the Kuterra land-RAS development ($5 million) and floating closed-containment development in Middle Bay, B.C. ($2 million). SDTC is working with DFO and the B.C. Government to advance new aquaculture production technologies, especially sensor and data technologies that will support sustainable growth of aquaculture in Canada.
- **Aboriginal Aquaculture in Canada Initiative (now under Northern Integrated Commercial Fisheries Initiative) –** This DFO led initiative supports development of Indigenous-owned communal commercial fishing enterprises and aquaculture operations. Aquaculture development funding is available to help Indigenous communities and groups develop sustainable aquaculture operations. This includes costs to expand or upgrade existing aquaculture facilities, for materials required in new and expanded operations, and those associated with entering into an aquaculture business. The intent of this funding is to support capacity-building, revenue and profit generation, employment generation, and self-sustainability of aquaculture operations.
- **Innovation, Science and economic Development (ISED) Canada Super Cluster Initiative –** This is a five-year $950 million funding program with a sunset in 2022, including an Ocean Supercluster. This is the first program of this nature in Canada where funding is delivered to industry-led consortia of businesses, post-secondary institutions, research and government partners. The Ocean Supercluster involves industries such as: marine renewable energy, fisheries, aquaculture, oil and gas, defence, shipbuilding, and transportation. The technology and innovation focus is: digital sensors and monitoring, autonomous marine vehicles, energy generation, automation, marine biotechnology and marine engineering technologies; and
- **NRC Industrial Research Assistance Program –** This program is designed for all stages of innovation in small and medium enterprises (SMEs), and offers financial assistance, advisory services, and connections to experts in Canada.

5.7 Outlook

There is excitement across industry, government, and ENGOs at the prospect of transforming aquaculture production and realizing its full potential. After many years of commercial scale solutions remaining elusive, there is no doubt that technologies now offer the means to improve performance. Environmental, social, and economic objectives can be advanced simultaneously. Popular press articles speak of “inflection points”, “tipping points”, “game changers” when describing commercial projects going forward around the world.

The new technologies discussed in this report, as well as conventional netpen systems, will all play a role in contributing to global production of salmon products. They will compete with one another for investment and expansion opportunities, and they will also compete with other seafoods and protein sources among the choices available to consumers. While certain higher-end product forms (e.g. sushi, smoked salmon), market channels (e.g.

restaurants, specialty food stores), and countries may initially help new technologies succeed, the increasing global supply of salmon will ensure the majority of salmon is sold to price sensitive buyers. New technologies developed in Canada must continually seek efficiencies to match low-cost competitors and remain competitive through periods of price variability.

Setting the course for new production systems in B.C., done properly, will move aquaculture beyond the contentious debate that has afflicted the sector for decades. New technology should be facilitated and encouraged so that improved systems replace existing ones. This will not automatically happen within the aquaculture sector and will require a coordinated and concerted effort to put in place incentives, clear requirements, and the innovation culture that is critical. Building on partnerships between companies, other coastal resource users, Indigenous communities, and governments, a collaborative approach will allow all interests to participate in future success.

Key findings and next steps:

- **Advancing performance -** Each of the production technologies can advance environmental, social, and economic performance of salmon aquaculture in B.C.;
- **Commercial readiness -** Land RAS and hybrid production technologies are ready for commercial development in B.C., while floating containment and offshore production systems need up to 5 years and 10 years respectively to evaluate their potential;
- **Legislation and policy –** A clear national legislative and regulatory framework is needed for aquaculture that supports future development of production technologies;
- **Innovation culture –** Collaboration between industry, government, Indigenous people, academic, and other research centres requires concerted efforts to facilitate information sharing and support for research that addresses challenges;
- **Biomass allocation –** Investment will follow growth opportunities so approvals for more biomass production, especially in the marine environment, must be tied to requirements that are met by the higher performance of new production technologies;
- **Financial incentives –** Existing funding for aquaculture innovation and Indigenous participation need to be prioritized and expanded, and eligibility for funding programs available to other industry sectors pursuing sustainable development needs to be examined;
- **Technology-specific measures –** Identification of suitable sites is needed for land-based RAS production and offshore commercial development. Research support and financial incentives are more appropriate for hybrid systems and floating containment respectively; and
- **Leadership –** Countries currently leading aquaculture innovation developments have taken bold steps to advance environmental, social, and economic objectives together. Canada's aquaculture sector can grow rapidly to a level on par with global leaders with leadership from all key players.

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A summary of the Indigenous and Multi-stakeholder Advisory Body (IMAB) on aquaculture engagement process

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Introduction

This document entitled: ***A Summary of the Indigenous and Multi-stakeholder Advisory Body (IMAB) on Aquaculture Engagement Process*** is an overview of the views and comments received by the Department of Fisheries and Oceans during in-person engagement sessions held with members of Indigenous communities and organizations, the Government of British Columbia, regional governments, environmental non-governmental organizations (ENGOs) and the finfish and shellfish aquaculture sectors from August 2019 until June 2020 as well as additional comments submitted in writing until August 7, 2020.

The purpose of the engagement sessions and reports produced through the process are to inform the Department's future actions regarding the sustainable management of aquaculture activities, including both finfish and shellfish aquaculture, in British Columbia.

We would like to thank all of the IMAB members and their representatives who actively participated in the engagement process, including its supporting Technical Working Groups (TWGs), for the knowledge, expertise and advice that they keenly provided during each meeting and in the development of the three TWG reports. While there may not have always been full agreement among the members on all issues examined, the process resulted in new knowledge, new ideas and new relationships that will inform improvements to the aquaculture industry in British Columbia for years to come.

Background

Aquaculture, including both finfish and shellfish production, is an economically and socially important industry in British Columbia worth over $814 million and generating approximately 1600 direct jobs and spin-off opportunities many of which are located in rural and Indigenous communities. Despite the sector's economic importance, some Indigenous communities and other stakeholders continue to express concerns related to the potential impacts of the industry on aquatic ecosystems and species, notably wild salmon.

In response to these concerns, in December 2018, the Minister of Fisheries and Oceans announced that "Canada would work in partnership with the provinces and territories, industry, Indigenous partners, environmental groups and other stakeholders to ensure an economical and environmentally sustainable path forward for aquaculture." As a step toward fulfilling this commitment, on June 4, 2019, the Minister announced the creation of a senior-level Indigenous and Multi-stakeholder Advisory Body (IMAB) on aquaculture that would be supported by three Technical Working Groups (TWGs) including a Salmonid Alternative Production TWG, a Marine Finfish and Land-based Fish Health TWG, and an Area Based Management TWG. The IMAB included twenty-seven members, official observers and ex-officio members from the federal and provincial government, local government, Indigenous organizations and communities, ENGOs and the aquaculture finfish and shellfish industries. Each of these organizations then nominated members to participate on each of the three TWGs. Each TWG was assigned specific terms of reference aimed at advancing the IMAB's objectives of promoting exchanges of knowledge, identifying opportunities for collaboration and developing specific recommendations to improve the sustainability of aquaculture in British Columbia.

Overview of engagement process

The IMAB engagement process included three face-to-face meetings (two in-person and one virtual meeting due to the COVID-19 pandemic) as well as several written exchanges and submissions toward the end of the process in Summer 2020. The engagement process was formally launched with a kick-off meeting in August 2019 during which IMAB and TWG members were introduced and draft terms of reference for the IMAB and its three supporting TWGs were distributed for review and endorsement. Following numerous meetings and extensive work by the three TWGs during Fall and Winter 2019-20, a second IMAB meeting was held in February 2020 to review the progress they had achieved and allow the IMAB members to comment and provide advice to the TWGs for completion of their mandates. Following the submission of TWG final reports, a final (virtual) IMAB meeting was held on June 15, 2020 to review and discuss the results and recommendations presented by each of the TWGs. The engagement process closed with the submission of remaining comments from IMAB members by August 7, 2020.

The final results of the engagement process include this summary document, *A Summary of the Indigenous and Multi-stakeholder Advisory Body (IMAB) on Aquaculture Engagement Process,* along with links to the three TWG reports provided below:

- Salmonid alternative production technologies TWG report
- Marine finfish and land-based fish health TWG report
- Area Based Management TWG report

A formal response to the recommendations contained in the three TWG reports will be provided in late Fall 2020.

Summary

General comments about the IMAB process

Based on discussions held during the three IMAB and the TWG meetings, and comments received in writing, it was clear that members were passionate about the role of the aquaculture industry in British Columbia and its potential impacts on marine ecosystems, notably wild salmon species. The importance of wild salmon to Indigenous peoples for food, social and ceremonial purposes was particularly highlighted throughout the discussions.

The majority of the representatives who participated on the IMAB and/or one of its three TWGs, expressed positive opinions about the engagement process highlighting the value of drawing together diverse interests to share information and perspectives and to collectively identify strategies and actions with the potential to improve the sustainability of aquaculture. Several participants acknowledged how the process had helped to bring forward new information and ideas and develop new connections and collaborations with some expressing a desire that discussions continue past the end of the formal engagement process. Others applauded the strong focus on science and recognition of the importance of incorporating traditional knowledge to improve the availability of data and information as well as the recommendations by all TWGs for enhanced communication on efforts to manage the industry with aquatic stakeholders. The Deputy Minister of Fisheries and Oceans Canada remarked that the engagement process had been very productive resulting in substantial submissions and recommendations for improving the sustainability of aquaculture in British Columbia.

Nonetheless, there were some participants who expressed less positive opinions about the overall engagement process and the Fish Health TWG in particular. Concerns were expressed over DFO’s leadership of the process, with the suggestion that it should have utilized an independent process, as well as the limited representation of Indigenous participants on the IMAB and the three TWG’s. Some Indigenous participants also suggested that their concerns were not always captured or watered down. It was also observed by some members that the process should have been further oriented to advance the Minister of Fisheries and Oceans commitment to transitioning open net-pens in British Columbia. With respect to the FH TWG, specific concerns were raised over: the scope of the working group's mandate (suggesting it should have included a wider consideration of the health and productivity of wild salmon species); the limited amount of time allowed for discussions as well as the preparation and review of key technical documents; the participation of ex-officio members in FH TWG meetings; and perceptions of bias by the Chair. Despite these concerns, these participants were unanimous in their view that the Department should continue to support multi-stakeholder engagement on issues related to aquaculture management in British Columbia.

Irrespective of the views on the engagement process itself, a key message that was expressed by those both for and against aquaculture is the need for Indigenous communities to have a direct voice in the types and/or levels of aquaculture activities that occur on their territories.

Salmonid alternative production technologies

According to its terms of reference, the SAPT TWG was assigned to:

- Review relevant reports and information related to intensive aquaculture (e.g. The State of Salmon Aquaculture Technologies, the Fraser Basin Council's RAS Atlantic Salmon Industry on Vancouver Island Financial Model & Economic Impact Analysis) and any other relevant information to assist the TWG in meeting its objectives; identify gaps; and provide recommendations.
- Propose for consideration, a series of objectives for alternative technologies which lower environmental risk factors related to pathways of effects (reduce interactions with wild fish; reduce benthic impact; reduce or eliminate genetic interactions, reduce environmental

impacts) and/or improve the efficiency/cost/environmental health outcomes for marine finfish aquaculture.
- Identify opportunities for collaboration and partnership for all stakeholder groups and Indigenous communities that can advance improvements which can be made relating to the potential adoption of new technologies in the Pacific Region.
- Identify key risk factors that may hinder or slow the adoption of alternative technologies. Propose solutions to minimize risk factors.
- Propose actions (i.e. ideas and strategies) that could attract investment into the BC aquaculture sector, allowing for sustainable growth.

In response, the SAPT TWG provided a report to the IMAB including a detailed analysis of existing hindrances and proposed recommendations to assist the development and adoption of alternative production technologies in four key areas including: Land-based closed containment (i.e. Recirculating Aquaculture Systems); Floating semi-closed containment systems; Hybrid systems (combination of land-based or floating semi-closed containment with traditional marine-based systems); and offshore systems. Strategic recommendations of the TWG focused on the need for:

- A site permitting, licensing and regulatory framework including:
    - Establishment of a permitting and regulatory framework with clear requirements, service standards and license durations to attract investment;
    - Introduction of the concept of developmental licenses/tenures.
- Financial incentives;
    - DFO and Provinces work together to develop financial incentives such as loan guarantees, tax exemptions, capital cost allowances, and Grants and Contribution support.
    - Development of a Community Futures Fund (seed funding);

    - Enhanced access to terrestrial farming financial support tools (e.g. Business Risk Management); and
- Capacity support including knowledge, human resources, and access to seed stock (biotechnology) including:
    - Support for science and industry driven R&D
    - Support for education and training in alternative production systems; and
    - Enhanced access to genetic materials (e.g. eggs) for alternative production systems.

While there was general support for the SAPT report and its recommendations, there was considerable debate amongst a few IMAB members over two key elements including: (1) the completeness of the cost data used in the analysis of land-based (RAS) production; and (2) whether or not there is sufficient data from large-scale (>3000 mt) production facilities from which to adequately determine cost estimates.

On the first issue, there was criticism of a chart included in the report providing estimated costs for the different types of alternative production systems as it was indicated that it was missing data from a 2019 Gardner-Pinfold study which identified lower capital costs for land-based aquaculture production. The omission was acknowledged and the table in the TWG report was updated to show a greater range in capital costs for land-based production.

On the second issue, there was denunciation of a statement prefacing the cost table that "… there are no large-scale (>3000 mt) land-based RAS facilities in production" with an IMAB member pointing to the Atlantic Sapphire's Miami Bluehouse facility in Florida as an example of a large-scale production facility. This example was opposed by an industry representative who pointed out that while the Atlantic Sapphire is a large scale facility, that it has yet to harvest fish and thus prove its commercial viability. The previous member indicated, however, that harvesting from the facility had begun as of July 2020 [1]. Additional differences in opinion were also expressed over whether or not such a facility, which currently discharges waste into a subterranean aquifer in Florida, could be utilized in British Columbia given substantial differences geological formations between the two regions.

Finally some ENGO members raised concerns over recommendations supporting floating semi-closed containment and hybrid production systems which they suggested are unable to eliminate wastes from entering the ocean and control the transmission of parasites or pathogens from farms to wild Pacific salmon.

Marine finfish and land-based fish health

According to its terms of reference, the FH TWG was assigned to:

- Undertake a review of existing marine finfish aquaculture fish health management regimes internationally, including data collection requirements, standards and management metrics, and corresponding management approaches to fish health;
- Review previous audits and assessments of Fisheries and Oceans Canada's fish health management regime; and
- Recommend improvements to the Pacific Region's fish health management regime, including:
    - Looking at what is measured and why;
    - Recommending standards and metrics for tracking and reporting and enhancements to the rigor and transparency of data;
    - Recommendations for creating 'greater certainty' in fish health, reducing risk, or mitigating potential adverse outcomes;

- Recommendations for how to better detect, respond to and manage fish health; and
- Recommending more clear rules for compliance and penalties for non-compliance.

The FH TWG was the most active of the TWGs meeting a total of ten times between August 2019 and May 2020. Additionally, with support from DFO to implement one of their early recommendations, they convened a two-day workshop of veterinarians and veterinary pathologists to review the Department's current case definitions for HSMI and Jaundice Syndrome. The FH TWG was unique in that it was co-chaired by DFO and the Canadian Food Inspection Agency (CFIA) as both departments share a responsibility for the management of aquatic species health.

Discussions among the participants mostly focused on DFO's overall management of fish health at aquaculture facilities with a particular concentration on the assessment and management of risks associated with Piscine Orthoreovirus (PRV), Heart and Skeletal Muscle Inflammation (HSMI), Jaundice Syndrome and, sea lice.

While all TWG participants were highly engaged, working group members often held divergent views regarding the interpretation of scientific data, what scientific data was relevant, and appropriate management responses, along with real and/or perceived biases that often resulted in friction among the participants. Despite this, the FH TWG was successful in reaching agreement on several issues and tabled consensus recommendations to DFO to address identified science, communication and management gaps related to aquaculture fish health management, environmental impacts and associated public confidence.

Specific recommendations included:

- Improvements to the existing Pacific Marine Aquaculture Management Regime which included:
  - improvements in communications and increased accessibility to data by the public;
  - improvements in access to scientific data, including that collected by external organizations,
  - development of tools to enhance fish welfare and establishment of quantitative indices of fish health (wild and cultured); and
  - strengthening of an “adaptive management” framework, including performance management, improved enforcement tools (e.g. ticketing) and adoption of international best practices as the minimum standard of fish health management.
- Improvements to Conditions of License for on-farm management of sea lice including:
  - Strengthened enforcement tools, increased sea-lice monitoring (including establishment of area-level thresholds), conducting pre- and post-treatment lice counts, implementation of integrated pest management, and mandatory requirements to submit environmental data.
- Improvements to knowledge and management of sea lice including:
  - Implementation of spatial and temporal monitoring, making sea lice data publicly available in near real-time, research on sea lice viability following chemical treatments, and consideration of third-party certification bodies; and
- Some actions to address concerns over the management of PRV, HSMI and Jaundice Syndrome including:
  - PRV challenge studies on all species of salmon, review of case definitions for Heart and Skeletal Muscle Inflammation (HSMI) and Jaundice Syndrome to ensure conformity with international best

practices and strengthened collaboration with CFIA to ensure effective monitoring of emerging diseases as well as sub-lethal signs of disease.

Several IMAB members positively acknowledged Fisheries and Oceans Canada's responsiveness to incorporate early recommendations from the FH TWG into its 2020 revisions to Conditions of License to improve sea-lice management. Other members, however, expressed the view that the revisions fell far short of what was needed to mitigate the impacts of sea lice transmission from aquaculture farms to vulnerable wild salmon populations.

Some IMAB members also acknowledged the Department's support to hold a workshop of qualified experts to review its current case definitions for HSMI and Jaundice Syndrome to ensure that the definitions are robust and conform to international standards. Although all TWG members were invited to nominate a facilitator and participants for this workshop, some IMAB members were critical that the workshop was not open to observers, with some indicating little trust in the outcomes of a process they were not able witness.

A few IMAB members were also critical of the management of the FH TWG. Particular concerns were expressed over the number of *ex-officio* DFO and CFIA officials who participated in TWG meetings, the amount of time given to review and discuss materials shared with TWG participants, and how members views were captured in the final FH TWG report. These concerns contrasted with those of other participants who deemed the participation of the *ex-officio* members to be essential to ensure the group's understanding of detailed scientific and technical information related to fish health and the department's current monitoring, auditing and evaluation practices.

As the FH TWG was unable to reach agreement on several issues including: the role of PRV in disease development, in particular HSMI and Jaundice Syndrome; the need for surveillance of additional strains of PRV in British Columbia; the role environmental conditions play in the development and transfer of sea lice to wild salmon; and the extent to which poorly performing farm-raised fish serve as indicators of the health of farmed and/or wild salmon; some IMAB members expressed an interest in continuing engagement on these and other Fish Health issues but expressed a preference that these discussions take place through an independently-led process.

Area Based Management

According to its terms of reference, the ABM TWG was assigned to:

- Conduct a review which highlights the following:
    - Relevant examples of approaches to Area Based Management in a fisheries and aquaculture context.
    - Use of various geographic scales as a management tool and assess their appropriate role in an Area-based Management of Aquaculture approach.
    - Information management technologies used in other related initiatives (like conservation planning, GIS analysis).
- Develop a recommendation for a shared definition/vision for Area Based Management of Aquaculture within Pacific Region.
- Supported by the above, recommend the use of appropriate scale/models for application in an area based aquaculture management approach in the Pacific Region (linkages to governance and engagement; planning; assessment of applications; management, monitoring, and science/research).

- Recommend appropriate technologies or approaches which could support the above.

Participation on the ABM TWG was highly collegial with good progress made against almost all of its assigned objectives. Several members of the TWG indicated that they would be happy to remain involved to assist with further development of the approach and framework for implementation including:

- The establishment of a new tripartite (Indigenous-Federal-Provincial) governance structures responsible for the planning, management and monitoring of all forms of aquaculture in B.C.
    - The new governance structures should include: a province-wide Area-based Aquaculture Management Committee (BC ABAMC) and sub-regional Area-based Management Committees (ABMCs) supported by a Science/Knowledge support committee and an ABAM secretariat;
- Adoption of a nested approach including establishment of pilot areas identified through proactive engagement with Indigenous rights and title holders;
- That ABAM areas be selected based on: Indigenous consent; consideration of environmental goods and services; Industry presence and/or potential; existing administrative boundaries; and other relevant factors;
- That financial and human resources be sought by all parties to support adoption of an area-based approach;
- That the approach consider the recommendations of the SAPT and FH TWGs;
- Additional assessment of tools supporting the adoption of an area-based approach and the establishment of a unified federal-provincial-Indigenous data sharing platform; and

- The integration of Area-based Management within the new federal *Aquaculture Act*.

Most IMAB members were supportive of the ABM TWG's recommendations. There was particular support for the recommendation to establish a tripartite governance structure for the planning and management of aquaculture activities in B.C. which some suggested would be consistent with the United Nations Declaration on the Rights of Indigenous Peoples.

Some questions were raised about the proposed framework, including whether the boundaries of Indigenous territories were considered and how Indigenous communities would be involved in the future development and implementation of the proposed framework. Some members explicitly expressed the requirement to recognize the rights and autonomy of First Nations to participate and that financial support be provided to build capacity and enable them to play meaningful roles in the proposed framework.

Additional concern was expressed over whether or not existing aquaculture activities should be included in the determination of proposed boundaries for management areas, suggesting that this would effectively grandfather these activities. Concerns were also expressed that the proposed framework must be able to address cross-boundary issues such as salmon migration. There was positive acknowledgement of how the adoption of an area-based approach could be used to help address sea lice issues.

Finally, some IMAB members expressed that they wished the TWG had gone further towards implementation, including the definitions of roles and responsibilities, and using the proposed framework to advance the Minister of Fisheries and Oceans mandate commitment of transitioning open net-pens in British Columbia.

Next steps

The next steps for the Indigenous and Multi-stakeholder Advisory Body on Aquaculture will include providing the Minister of Fisheries and Oceans this summary document, the three TWG reports, IMAB meeting minutes and written submissions received from IMAB members. Fisheries and Oceans Canada will formally conclude the IMAB engagement process by responding to the recommendations contained in the TWG reports in late Fall 2020.

We wish to once again thank all of the IMAB members and their TWG representatives for their dedication of time, knowledge and experience to this informative process.

Footnotes

1 On August 28, 2020 Atlantic Sapphire reported plans to harvest its first fish in September with plans to move to steady-state production from the first phase of its Miami Bluehouse facility in the first quarter of 2021. Land-based salmon farmer Atlantic Sapphire to start US harvesting in September.

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