Minister of Agriculture's Advisory Council on Finfish Aquaculture

Final Report and Recommendations

January 31, 2018

Letter of Transmittal

To: The Honourable Lana Popham, Minister of Agriculture

Dear Minister Popham,

On behalf of the Minister of Agriculture's Advisory Council on Finfish Aquaculture (MAACFA) I am writing to provide you with the council's final report and appendices. The report is the culmination of 18 months of deliberation in which our council heard from varied interests on marine-based salmon aquaculture in B.C. Our advice and recommendations take into consideration the diverse views we heard, as well as the divergence in our own members' perspectives on salmon farming that emerged as we addressed the tasks outlined in our terms of reference. In undertaking these tasks our members participated as individuals, not as representatives of any particular group or organization with which they might be associated.

This report makes a number of recommendations refined over several meetings and as they evolved they were regularly distributed to members, thus allowing for a broad review by all members including those unable to attend meetings in-person.

Some members believe the recommendation do not to fully address their view of the harm to wild salmon posed by net pen aquaculture. For other members, however, the recommendations are a reasonable response to their perspective that the farms were of minimal risk to wild salmon. Nevertheless, all members of the council have indicated their support for these recommendations, which are structured in a way that reflects not only the role of your government but also the important role to be played by Fisheries and Oceans Canada in their successful implementation over the longer term.

Finally, the appendices provide further background information that supported the development of our recommendations on salmon farming, including presentations made to council, and an elaboration of perspectives on salmon farming held by a number of our members.

Our task was challenging, given the strong and often polarized views on salmon farming. Nonetheless our council has appreciated the opportunity to provide advice on a topic of great importance in British Columbia.

Yours truly,

Paul Sprout

Paul Sprout
Chair, Minister of Agriculture's Advisory Council on Finfish Aquaculture

Cc: Council members

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1.0 Introduction

This report presents the findings and recommendations of the Minister of Agriculture's Advisory Council on Finfish Aquaculture (MAACFA). The council was formed in 2016 by the Province of B.C. with the stated scope and purpose "to provide strategic advice and policy guidance to the Minister of Agriculture about the future of, and issuance of new Crown land tenures for, marine-based salmon aquaculture in B.C."

The terms of reference noted the council's "deliberations may include whether or not the Province should pursue development of marine-based salmon aquaculture in B.C. and if so, should yield recommendations to guide the application and approval process to ensure that aquaculture operations are socially and ecologically sustainable and can co-exist with British Columbia's wild fishery resource."

The council was instructed to provide a balanced and reasoned approach, mindful of divergent views, and was expected to reach consensus in providing recommendations. If not possible, the council was instructed to reflect the different views of the members. The full terms of reference are found in Appendix 1.

Initial appointments by the Minister of Agriculture were made in spring 2016 and additional members were added that fall to expand the already wide range of experience, expertise, knowledge and diversity of views on aquaculture. Appointees were to participate in council discussions as passionate and knowledgeable individuals as opposed to representatives of any group or organizations they may be affiliated with. The council membership is found in Appendix 2.

MAACFA met 12 times between July 2016 and January 2018 during which it was provided background on salmon farming (regulatory regime, operational arrangements, and research and health developments) and diverse presentations on finfish aquaculture issues. The council was informed of benefits, such as employment, that salmon farming provides to communities, and its economic importance to B.C.'s economy. Others highlighted the biological risks that farms posed to wild salmon and their view of the applicability of the precautionary principle to deal with uncertainty and knowledge gaps existing around salmon farming.

After careful consideration of the issues brought forward the council is proposing a number of recommendations aimed at easing the controversy surrounding net-pen aquaculture by reducing the potential risk to wild salmon, improving net-pen salmon farm siting, and by increasing transparency and community and First Nations involvement in aquaculture-related decision making. Council members diverge on their views on the level of potential risk that farms pose to wild salmon and as a result views on how to address the overall risk of salmon farming are not uniform. As set out in the council's terms of reference, these differences are acknowledged in this report and are elaborated upon in appendices.

Despite the differences within MAACFA on the risk that farms pose, members share a common vision on the importance of sustaining wild Pacific salmon, the need for salmon farm practices to better align with this primary goal, and the importance for government and the industry to build greater trust among British Columbians.

At the time the council was announced the Province committed to examining the rules and restrictions that guide the application and approval process to ensure that aquaculture operations are socially and ecologically sustainable and can co-exist with British Columbia's wild fishery resource. In addition to forming the council, the government said it would:

1. Examine establishing a protocol for receiving advice from the Aquaculture Stewardship Council in regard to tenures for new aquaculture sites.
2. Examine the feasibility of improved microbe detection at aquaculture sites arising from the work being undertaken by Genome BC in tandem with the other scientific evidence already available to the Province.

Although not in council's scope and purpose, the above topics naturally came up in council deliberations as they are tied to the subject of aquaculture. Recommendations have been made related to microbe detection. The council agreed not to comment on a protocol for advice from the Aquaculture Stewardship Council because we understood that the organization's mandate does not include provision of advice.

2.0 Report Development Process

The council held its initial meeting in July 2016, and its final meeting in January 2018. Meetings typically lasted two days and were held approximately every two months for a total of 21 days. During that time more than 20 presentations were heard and discussion topics ranged widely, always relating to the council's terms of reference and ways to collaborate on report development. Some MAACFA members visited a salmon farm in conjunction with a council meeting in Campbell River. On March 8, 2017 the council submitted an interim report to the Minister of Agriculture that noted it was working cooperatively towards fulfilling its mandate and outlined progress. Given the complexity of the task, range of perspectives, and volume of materials under consideration, the council requested, and was granted, an extension to the end of January 2018.

Initial presentations to the council focused on providing an overview of the finfish aquaculture industry in B.C. and how it is managed. Appendix 3 and Appendix 4 detail these presentations. Subsequent presentations captured the views of First Nations representatives, industry, environmental and community interests, scientists, veterinarians and academic experts in fields related to aquaculture as well as ecosystem and salmon health. Appendix 5 gives a brief summary of each presentation.

Throughout its deliberations, the council witnessed that expert presenters held a wide and divergent range of views on the risks posed by salmon farming. Some view the environmental risk, in particular the potential risk of serious harm to wild salmon populations, is such that it makes net-pen aquaculture unacceptable. Others hold the view that properly sited and managed net-pen salmon farming poses no more than a minimal risk of serious harm, and they emphasize the positive income and employment benefits generated locally and provincially from salmon farming. This diversity of perspectives is also reflected in the views of MAACFA members. Accordingly, in preparing this report, the council has strived to develop advice to the Minister in a way that fairly and constructively acknowledges the range of perspectives and divergent views that were reflected in our deliberations, without attribution to specific members.

3.0 Context and Overarching Vision Guiding MAACFA's Deliberations

The council acknowledges that a wide range of activities in addition to net-pen salmon farming pose risks to wild salmon and their ecosystem requirements, including fishing of wild salmon; agricultural, urban, and industrial activities; and the effects of global climate change. Further, the council observes that eliminating all risks to wild salmon and their ecosystem is not a realistic, achievable objective. Nevertheless losses of wild salmon must be constrained through careful management that considers all risks.

In considering the future of salmon farming in B.C., the council noted the importance of understanding both the current and future operating context for net-pen salmon farming as the basis for developing its advice. In particular, the council observed the following:

> *First Nations* — First Nations rights and title continues to evolve and First Nations will have an increasing influence over salmon farming in their territories. The ongoing reconciliation of aboriginal rights is an important aspect of the operating context for salmon farming in the years ahead.
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> *Salmon Farming Practices* — Over the past 30 years, salmon farming practices have evolved and improved considerably. Improvements have been made, for example, in feeding efficiencies, preventing farm fish escapes, and fish health management. While this trend is encouraging, there is also the recognition that challenges now faced by the industry, such as pathogens and sea lice, may be some of the most difficult ones to address. Meanwhile there is an interest by industry and the federal government to support and expand the sector.
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> *Climate Change* — Climate change is creating oceanic and freshwater environments that are less predictable and prone to greater extremes, which are generally less favourable to both wild and farmed salmon alike. For wild salmon, lower ocean productivity and warm freshwater conditions pose a significant sustainability challenge. Changes in ocean conditions are also anticipated to result in some salmon farming sites becoming unusable, and producers can be expected to seek more

flexibility in the siting of existing farms. The *interaction* of climate change, farm conditions, and wild salmon will certainly increase uncertainty in future years.

All members of the council were united by an overarching vision despite having different views on aquaculture. This unifying vision guided the council's work and reflected a desire to sustain healthy and resilient populations of wild Pacific salmon by keeping the risk to them from net-pen salmon farming to a minimum, as expressed in the following vision statement:

"*Sustaining wild salmon within a healthy ecosystem while recognizing the interdependence and importance of wild salmon to communities in B.C.*"

Given the council's mandate to provide advice to the Minister of Agriculture about the future of marine-based salmon aquaculture, MAACFA members supported examining net-pen salmon farming from the perspective of its potential impact on the health of wild salmon populations, acknowledging the complex interactions and connections between human activities and salmon.

In pursuing the council's overarching vision, there was general agreement that complex interactions between wild salmon and humans have a potential impact on stocks and that greater collaboration and engagement is essential both for wild salmon health and to ease societal tensions around salmon farming. This includes extensive engagement of First Nations and ensuring that public concerns are recognized and addressed to the greatest extent possible. This would also include a requirement for government and industry to become more open and transparent about key aspects of salmon farming operations including the collection of specific scientific data and sharing this information in a timely and effective manner. Greater and early engagement, openness and transparency are critical factors related to public acceptability and building public trust associated with net-pen salmon farming. In addition, MAACFA noted that a resilient and healthy wild salmon resource would likely reduce public concern about interactions with farms. Consequently, greater attention to wild salmon restoration (including their habitats) and assessments is required to separate the effects of farms from changes in the natural environment.

4.0 The Future of Net-Pen Salmon Aquaculture

The council's terms of reference note that it's purpose and scope is to provide advice on the future of and issuance of new Crown Land tenures for marine based salmon aquaculture. Our deliberations may include whether B.C. should pursue the development of marine based salmon aquaculture and if so provide recommendations to guide the application and approval process to ensure that operations are socially and economically sustainable and can co-exist with B.C.'s wild fishery resource.

In considering is purpose and scope, MAACFA members agreed that risk to wild salmon populations presented by salmon aquaculture is the primary overarching issue and managing risk is the basis for developing our advice. But, there is no consensus on what level of risk is posed by operations or what level, if any, is acceptable. We refer to this as the "risk conundrum."

Council identified three perspectives on the acceptability of the risk among members. They are summarized below.

Perspective 1 — The risk of serious harm to wild salmon populations is too great to allow for the continuation of the net-pen salmon farming industry and therefore no new site tenures should be permitted, and existing tenures should be terminated expeditiously but in an orderly fashion. This view contends that the federal government is not applying the precautionary principle appropriately and net-pen salmon farming should cease unless it can be proven that salmon farms do not pose a risk of serious harm to wild salmon. This view also holds strongly that those who believe the risk of serious harm is tolerable or minimal should provide scientific backing for their positions. Refer to Appendix 9 for a more detailed description of this perspective, including reference to relevant scientific papers.

Perspective 2 — The risk of serious harm to wild salmon populations can be controlled through modern best practices and applying a more strategic approach to siting, which in the near-term would not see the net-pen industry expanding beyond current levels in B.C. This approach would encourage the relocation of some existing sites or possibly new sites where likely risks and impacts on wild salmon would be judged low. Alternative ocean technologies and land-based aquaculture should be pursued as opportunities to build on B.C.'s aquaculture sector and grow the economy.

Perspective 3 — The risk of serious harm to wild salmon populations come from a wide range of conditions and activities in addition to net-pen salmon farming, and no evidence has been provided to the council to suggest aquaculture poses a greater than minimal risk of serious harm to wild salmon. This perspective contends that there is an important social and economic upside to further developing salmon aquaculture as a key part of B.C.'s coastal economy and that the benefits far outweigh the potential harms and that net-pen salmon farms should be managed, using global best-practices, and permitted to increase in a manner that mitigates harm. Similar to perspective one, this view holds strongly that those who believe that the risk is unacceptable should provide scientific backing for their positions. Refer to Appendix 10 for a more detailed description of this perspective, including reference to relevant scientific papers.

There is agreement among council members that the discord in the debate of risk and harm to wild salmon from net-pen salmon farming — evident in the views of council members as well as across sectors including scientists, academics, First Nations, environmentalists, industry, and public officials — diminishes public trust in the salmon aquaculture industry and confidence in government efforts to protect and restore wild salmon.

While some members hold the view that existing tenures should be discontinued, all members recognize that the net-pen salmon farming industry will continue — at least transitionally — notwithstanding any government decision on its future. As a result, advice and recommendations can and should be made with respect to the way in which tenures are considered, issued and reviewed, and in the way farms are required to operate. All council members are willing to support recommendations for improved tenure decision-making and management processes for some period and on the understanding that some existing farms pose greater risks and have different levels of First Nation and public support. Council members have identified a number of themes for which a strategic recommendation can be made, with some suggested immediate and longer-term recommended actions to address the underlying areas of contention. These recommendations address fundamental questions raised by the council's terms of reference, including the relocation of existing farms to address First Nations, public and environmental concerns, the processes for engagement and capture of First Nations and public concerns, and a prescribed, area-based management approach to determination of sites for new farms or relocation of existing farms.

Members who view salmon farms as posing unacceptable risks to wild salmon suggest the solution is to move to land-based salmon farming in B.C. Other members believe that such an extreme response is unwarranted given their view that current salmon farms pose no more than a minimal risk of serious harm to wild salmon and that land-based salmon farming has not been proven to be financially viable at this time. Regardless, all council members support initiatives to develop land-based or other closed-containment salmon farming by those who wish to do so.

Our advice and recommendations — supported by all of the council and focused at a strategic level with immediate and longer term recommended actions — are aimed at addressing some of the underlying causes triggering the issues. It is acknowledged that the recommendations will not fully address the view of harm of net-pen aquaculture held by members desiring an expeditious transition to land-based farms.

5.0 Key Themes, Advice and Recommendations

The recommendations that follow are intended to address the main issues raised in presentations and subsequent council discussions and are aimed at providing a continuum of care by reducing known existing harms to wild salmon and the risk of future harms.

Harm reduction promotes relationships, structures and processes to make incremental gains towards safer, more sustainable situations. It could work to reduce negative social controversies of salmon farming. It emphasizes strengths, possibilities, and opportunities to reduce harms and it develops a hierarchy of achievable small wins that builds public trust through collaboration, despite differing opinions and uncertain evidence.

Its inclusion in our report reflects the council's desire to inspire new tactics to overcome entrenched perspectives and inaction to ensure progress on sustaining healthy and abundant wild salmon, irrespective of our diverse perspectives.
One of the most evident harms to public trust associated with net-pen salmon farming is the decades of social and scientific conflict. Resolving conflict in a collaborative way would

help to develop trust and strengthen communication channels. As a consequence, a major theme running through our recommendations is the importance of finding new ways to work together on aquaculture issues to better protect and sustain wild salmon and to increase the public trust required to reduce conflicts. While harm reduction focuses on reducing the known harmful consequences of an activity, it is neither a replacement for efforts to mitigate or eliminate risks to wild salmon.

The council's views on risk focused on the potential harmful biological impacts of salmon farms on wild salmon. When there is sufficient detailed data and technical expertise available, three factors help determine if the risk is high or low: (i) the probability of a hazardous event occurring; (ii) the duration and intensity of the exposure to the hazard; and, (iii) the consequence of the event occurring.

Two of the most significant risks related to salmon farms identified by the council are the transmission of pathogens between farmed and wild salmon — especially if a pathogen is not endemic to British Columbia — and the impact of sea lice from salmon farms on juvenile wild Pacific salmon. Council was advised that while risk assessments are underway, in most cases quantifiable assessments of risks are not currently available for pathogens of concern. Moreover, given the complex nature of pathogens and disease, significant uncertainty and knowledge gaps (often with respect to our knowledge of the state of wild salmon) exist in terms of the likelihood of pathogen transmission from farmed salmon to wild salmon and the potential effects of subsequent development of disease associated with such transfers. Therefore, in the absence of detailed risk assessments, perspective and belief are two factors that are often used by individuals to form their perception of risk.

In summary, a harm reduction approach is suggested as a new tactic to address the conflict that is occurring now. The harm reduction approach is complementary to other actions designed to reduce potential biological risk of significant harm to wild salmon. Refer to Appendix 6 for a more detailed description of both harm reduction and risk management in the context of salmon farming in B.C.

Information presented below is organized according to major themes identified by the council on the basis of presentations made, information provided, and council discussions. Council describes what was heard, summarizes our views of the issue — including where members diverge, and identifies a strategic recommendation and specific actions to respond to the issue immediately and in the longer term. Immediate actions are as those that can be put in motion or achieved relatively soon and are within Provincial responsibility. Longer-term actions require the collection of information, completion of studies, and regulatory change to implement and are actions that will require the involvement and cooperation of the Department of Fisheries and Oceans to fully implement. The recommendations are intended to address existing harms, particularly those related to ongoing conflicts, and to tackle the uncertainty about the biological risk to wild salmon associated with salmon farms. Appendix 7 further elaborates on the themes and the observations of council on these topics.

Theme 1 — Salmon Farm Locations

What We Heard and Council Observations

The council heard a range of concerns from presenters including First Nations about existing salmon farm locations. In summary, these concerns are as follows: some farms are located along the migratory route of major wild salmon populations raising concerns related to pathogen transfers; not all salmon farms are located in optimal sites with good flushing ability (i.e., where strong currents minimize potential negative impacts of harmful contaminants and wastes into the local environment, such as fecal material, excess feed and therapeutants); the density or number of salmon farms within a geographic area may increase the risk to wild salmon (i.e., the duration and intensity of being exposed to a potential hazard) and result in cumulative environmental effects related to a requirement for flushing that exceeds the natural capacity for exchange of seawater; and finally, climate change is anticipated to affect water temperature, salinity, and dissolved oxygen levels, and based on today's aquaculture technology will make some current salmon farming locations much less desirable.

The council also heard that an important factor related to sustaining wild salmon is their ability to avoid or recover from a disturbance, crisis or change. In effect, healthy and abundant wild salmon populations are more resilient and better positioned to withstand pressures such as the risks posed by salmon farming and other activities. In this context, the council recognizes the contribution that productive salmon habitat and reliable stock assessment information can make to wild salmon sustainability. As well, appropriately designed improvements in the collection and public dissemination of salmon stock assessment information would lead to a better understanding of the impact that the location of salmon farms have on wild salmon.

All council members believe that wild Pacific salmon should come first and the precautionary principle needs to apply. Consequently, council members support recommendations to government to encourage relocation of farms to reduce risk to wild salmon, improve alignment of farms with First Nations and community interests, adopt a new area-based management approach that considers cumulative risks and ensure that greater resources be dedicated to the assessment and restoration of wild salmon.

Strategic Recommendation

Strengthen the precautionary approach to regulating salmon farming in B.C. to reduce the potential risk of serious harm to wild salmon.

Immediate Recommended Actions

1.1. Adopt an area-based approach to managing salmon farms and initiate work to identify geographic areas and their management requirements, including the maximum number of *permitted net-pen salmon farms, and maximum total allowable biomass based on the environmental capacity and other scientific considerations. This approach should also examine the feasibility of locating salmon farms in areas with lower salinity and that may result in fewer sea lice.*

1.2. Place greater emphasis on the cumulative effects of multiple salmon farms operating in the same geographic area as part of site approval process and area-based approach to managing salmon farms.

1.3. Provide regulatory flexibility to relocate existing salmon farms to new sites based on the primary objective of reducing risks to wild salmon, in addition to other considerations such as addressing First Nations and community concerns and reducing the number of farms operating in sub-optimal locations.

1.4 Define in a prescriptive manner how the precautionary principle will be applied in the siting of salmon farms outlining its key elements and objectives.

Longer-Term Recommended Actions

1.5 Establish criteria to govern any future siting of net-pen salmon farms in B.C., including evidence that the farm poses no more than a minimal risk of serious harm to wild salmon, the location of the farm has First Nations support at the outset, and the location of the farm is favourable from an environmental perspective.

1.6. Increase investment in the assessment of wild salmon stocks, the public dissemination of stock assessment information and in the restoration of wild salmon habitat and other resources, such as Pacific herring, on which they depend.

Theme 2 — Aboriginal Rights and Title

What We Heard and Council Observations

The council heard both support for and opposition to net-pen salmon farming from First Nations on aquaculture. The council was informed that all First Nations, whether supportive or not, depend upon healthy ecosystems and continue to rely on wild fisheries and other marine resources for food and economic needs. The provincial and federal governments have a legal and a fiduciary obligation to protect and support First Nations' access to these resources, including access to wild salmon by First Nations whose territories include the inland streams that are wild salmon migratory routes.

Council were reminded that most First Nations on the coast do not have treaties and must be consulted and accommodated with respect to salmon aquaculture siting and operations in order to avoid infringement of aboriginal rights and title in their territories. First Nations are increasingly asserting their stewardship and management responsibilities and their ability to make decisions on land and marine use within their territories. Shared decision making with provincial and federal governments is a specific objective of First Nations, as reflected in recent shared marine planning work and in fisheries and ocean protection management discussions. This self-determination is now frequently recognized by the courts and is at the heart of the United Nations Declaration of Rights of Indigenous Peoples (UNDRIP) that includes reference to free, prior and informed consent by First Nations.

The council heard that both on the Pacific coast and in the B.C. Interior regions, First Nations seek a greater role in the monitoring, enforcement, science and research of all fisheries including both wild and farmed salmon in their territories and ultimately the development of true co-management structures and joint authority with other governments that includes the review and adjudication of farm tenures and licences. However, human resource and financial capacity limitations make it difficult for many First Nations to engage in these activities. When properly resourced, many First Nations have rapidly developed capacity to engage in these activities including significant increases in monitoring capability through marine watchmen and other programs. First Nations communities are an important source of traditional knowledge and a growing body of scientific information concerning marine ecosystems.

It is apparent to the council that First Nations support has become a major factor in determining acceptability of net-pen aquaculture siting and operation and salmon farming companies in B.C. have been proactive in working with First Nations. Currently they have 20 economic and social partnerships with coastal First Nations and 78% of B.C.'s annual production of farm-raised salmon is harvested from areas covered by agreements with First Nations. Yet some First Nations have operating farms in their territories and want them removed.

For new farm site applications, salmon farming companies in B.C. have developed internal guidelines requiring First Nations participation, and have been proactive in this endeavour resulting in economic and social partnerships with coastal First Nations. However, the ability to secure First Nations support is complicated in many areas by the existence of shared traditional territories, in which some First Nations may support a salmon farm while others are opposed. Irrespective of their individual positions, First Nations desire greater involvement in monitoring of farm operations as well as greater involvement in and access to scientific information being collected on farm operations and effects. Their overall concern about the viability of wild salmon is reflected in their strong support of improved salmon stock assessment and increased efforts in salmon habitat restoration.

All council members support an increasing and expanding role and influence of First Nations in all aspects of salmon farm planning, siting, decision-making, and management processes.

Strategic Recommendation

Acknowledge and incorporate First Nations' rights, title and stewardship responsibilities in all aspects of fish farm governance, including tenuring, licensing,

management and monitoring in a manner consistent with the United Nations Declaration of Rights of Indigenous Peoples (UNDRIP).

Immediate Recommended Actions

2.1. Establish policy requiring industry to have agreements with a First Nation(s) affected by a net-pen aquaculture site as a condition of any new or replacement site tenure, and provide guidelines to industry for developing these agreements.

2.2. Review and strengthen B.C. government engagement processes with individual First Nations governments on new or replacement net-pen aquaculture site tenures.

2.3. Establish a salmon aquaculture forum comprised of coastal and B.C. Interior First Nations organizations — and where possible using appropriate existing provincial and federal advisory bodies — to provide advice on net-pen aquaculture management issues such as site applications and farm operations in First Nations shared territories.

Longer-Term Recommended Actions

2.4. Develop a program and secure funds to support additional First Nations capacity for engagement in review of new and replacement net-pen aquaculture site applications, and for subsequent engagement in related science, management, monitoring and enforcement.

2.5 Increase involvement of First Nations in the planning, management and operation of salmon stock assessments and salmon habitat restoration projects.

Theme 3 — Marine Planning and Community Engagement

What We Heard and Council Observations

The council heard a consistent message about the importance of resolving conflicts and increasing public trust, through planning and through greater local community influence over salmon aquaculture siting. This message included a harm reduction model, as described earlier and in Appendix 6. We also heard that for supportive communities (including First Nations communities) there are demonstrable benefits to community well being (Appendix 5).

The council heard that aquaculture governance in Norway places heavy emphasis on spatial planning, and that local government spatial plans determine whether or not a farm site will be considered (Appendix 5). Moreover, this consultation and planning occurs very early in the process. We also heard that four marine spatial plans have recently (2015) been jointly developed by B.C. and First Nation aggregate organizations, covering the area from Campbell River to Haida Gwaii. These plans, which started at the 'community level', specify whether or not, where, and under what conditions, aquaculture site applications should be accepted by B.C. for processing. These plans were developed with advice from local governments and key stakeholder groups and subjected to public review. Other coastal plans that provided similar direction to government for tenure applications were completed by B.C. in the 1990s with input from some local First Nations, and are in need of updating. There are also areas of the coast that have no such spatial plans available. The council was informed that the B.C. government has made the reinvigoration/modernization of planning as one of its top priorities. The council endorses such an endeavour.

On community engagement, the council was provided information on the nature of community, stakeholder and local government engagement in net-pen aquaculture applications (see Appendix 4). For new net-pen aquaculture tenure applications, public open-house meetings are required, in addition to other public comment opportunities. Currently this critical input occurs only after an application is accepted for processing, which is poor timing to engender public support. An overview of and summary of all comments received is included in the land-use report prepared by B.C. staff for decision-making. For renewal of tenure and licences, community engagement and local government review opportunities do not exist, which is consistent with current policy for all public land tenures issued by B.C.

The council believes that the long history of public debate, continued controversy and public trust issues associated with salmon farm siting warrants increased opportunities for community, public and local government perspectives. Community and local government perspectives may change over time, and so it is important to assess any changes in public trust levels related to site location and farm operations before replacement tenure is considered. There may be efficiencies to be gained in encouraging applicants to hold community meetings in advance of formal site applications, where no other guidance exists in the form of marine plans and zoning bylaws.

A number of standing advisory committees exist along the coast to provide input on federal and provincial resource management activities and these standing committees generally include First Nations, community and stakeholder representation. Expanding the mandate and providing financial support to relevant advisory structures to include salmon farming issues would build on existing, well-functioning structures to address public trust, disseminate information and help reduce conflicts.

Strategic Recommendation

Increase community, stakeholder and local government engagement and marine spatial planning to improve public trust in aquaculture siting and operations.

Immediate Recommended Actions

3.1. Require applicants to engage affected communities and local governments and provide documentation of feedback prior to submitting applications for new net-pen aquaculture sites.

3.2. Require community meetings and local government review of replacement net-pen aquaculture site tenures and the inclusion of resulting comments in the replacement tenure decision-making process.
3.3. Establish and support stakeholder and local government advisory committees for new and replacement site and licence applications and for aquaculture spatial planning activities, utilizing appropriate existing provincial and federal advisory committees where possible.

3.4 Direct B.C. staff to follow siting and tenure management direction found in recently completed B.C. – First Nations approved marine spatial plans when making decisions on new and replacement tenure applications for net-pen aquaculture.

Longer-Term Recommended Actions

3.5. Identify and apply appropriate B.C. regulatory tools to reinforce the direction provided on net-pen finfish aquaculture siting and tenure management in existing, approved marine spatial plans developed and approved by B.C and First Nations.

3.6. Update appropriate existing B.C. coastal spatial plans and initiate new collaborative marine spatial plans for currently unplanned areas, to provide direction on net-pen aquaculture siting.

Theme 4 — Pathogens and Disease

What We Heard and Council Observations

The council observed that the risk of pathogen transfer between wild and farmed salmon is perhaps the most controversial topic currently facing the salmon farming industry in British Columbia and worldwide.

Of particular concern is the possibility of a catastrophic decline in wild salmon populations if a highly virulent pathogen (e.g., an exotic pathogen or mutation of a virus) was to be transferred to wild salmon. However, the council did not receive definitive data on the harm produced to wild salmon populations by pathogens. Instead, it heard perspectives on the risks. In terms of the risk of pathogen transfer between wild and farmed salmon, the council heard differing views from several scientists and veterinarians, and council members themselves.

One view, supported by some council members, was that while pathogens do transfer between wild and farm salmon, many viral diseases (e.g., ISAv, IPNv, Omv, Sav, PMCv, and ASPv) are absent on salmon farms, that less than 1% of farmed salmon die per year of significant disease and that if diseases that do not spread inside the farm where the risk of exposure is considerably higher than in the wild (especially for diseases that farmed salmon have not been vaccinated against) then such diseases pose minimal risk outside the farm. Some council members viewed this as evidence that the risk to wild Pacific salmon related to pathogen transfer from farmed salmon is low.

Conversely, other council members questioned the credibility of this evidence noting that some data being referenced was not available to the public. These members observed that the council had heard that up to 12% of farm audit samples died of unknown causes, that piscine reovirus (PRV) is highly prevalent in farmed fish (approximately 70% of B.C. farm audit samples), that PRV can be transferred to wild fish (laboratory studies), that heart and skeletal muscle inflammation (HSMI) has been reported from one salmon farm in B.C., and that PRV was associated with pre-spawning mortality of Fraser sockeye. As well, the Strategic Salmon Health Initiative (SSHI) has identified a number of novel viruses that require more study. Some Council members viewed this as sufficient evidence to argue that the risk related to pathogen transfer between wild and farmed salmon was high.

The council heard that the Level 2 wet laboratory capacity in B.C. is inadequate, significantly limiting understanding the effects of pathogens on Pacific salmon. For example, within the SSHI, new viruses have been detected but to understand their effect on Pacific salmon "challenge studies" are required. These would expose Pacific salmon — reared under controlled conditions — to the virus to assess effects. A Level 2 containment laboratory is a biosecurity designation set by the Centers for Disease Control and Prevention. For studies of Pacific salmon these laboratories required multiple rearing tanks (of various volumes), controlled environmental conditions for freshwater and seawater, and effluent treatment for discharges (airborne and in water).

The council was informed that sea lice are endemic pathogens that found on wild fish (e.g., salmon, herring and stickleback) and on farmed salmon. There are two types of sea lice found on salmon — *Lepeophtheirus salmonis* (leps) and *Caligus clemensi* (Caligus). The council heard a number concerns about sea lice, in particular that migrating B.C. juvenile salmon face greater pressure to sea lice as a result of salmon farms and that salmon farms amplify sea lice on juveniles.

Again, the extent of harm to wild B.C. salmon populations from sea lice is unknown, but several presentations to the council contained correlational information regarding louse impacts on wild salmon. The council heard that Caligus sea lice can impair feeding and growth of wild salmon and increase predation risk. The council also heard that there is no evidence of resistance to the particular sea lice therapeutant called SLICE although evidence exists in Europe. While leps are actively managed on B.C., salmon farms, Caligus is not. Thus, the council observed that there are ongoing concerns about wild salmon potentially facing greater exposure to sea lice as a result of salmon farms. A better understanding is needed of the impact of this exposure.

The council was advised that the management/control of sea lice in farms was an important issue and cost to the industry as evidenced by continued efforts to find alternative treatments via therapeutic controls, research into vaccines, and recently, the building of ships (see 2017 BCSFA Stewardship report) to be used as a "closed container" within which to de-louse fish during their farm-production cycle.

The council heard presentations that sea lice posed a threat to wild Pacific salmon. However, we were also informed that continued investment and research, changes in area management of farms to limit production consistent with the abundance of wild salmon, and greater emphasis on the restoration of healthy, abundant wild Pacific salmon populations should be pursued to help address the concerns.

The subject of pathogen and disease transfer is one where council views diverged the most, including different views on the existence and quality of data to support findings, and there remains considerable scientific debate concerning the potential impact of viral infections on wild salmon. Council members agree that the uncertainty surrounding this topic warrants advice to government in the event that government decides the industry should continue at its current or expanded levels.

Finally, council is writing this report at a time when the science around aquaculture is vigorously debated and indeed is evolving at a rapid rate. This is particularly true on the question of pathogens and pathogen transfer.

Strategic Recommendation

Move expeditiously to better understand the risk salmon farming poses to wild salmon from the transfer of pathogens (including sea lice) as well as the actual consequences of pathogen infection on wild salmon.

Immediate Recommended Actions

4.1. Establish as soon as possible an independent science council, with the support of the federal Department of Fisheries and Oceans, comprised of non-government scientists with a mandate to address "conflicting science", identify information gaps, provide advice on future research priorities and communicate to the public and appropriate advisory committees on behalf of the scientific community about salmon farming.

4.2. Conduct additional scientific research to better understand the potential effects of pathogens transferring from farmed salmon and producing disease in wild salmon.

4.3. Continue monitoring sea lice levels on B.C. salmon farms and on juvenile wild salmon; monitor populations of wild salmon in proximity to salmon farms; and, test on a regular basis the effectiveness of treatments in controlling sea lice levels and for resistance to sea lice therapeutants.

4.4. Increase the capacity of B.C. Level 2 wet lab facilities in order to conduct work required on pathogens.

Longer-Term Recommended Actions

4.5. Contribute funding and engage with the federal Department of Fisheries and Ocean around its work to create a new research framework to identify future directions on research and collaborations to be done at the Pacific Science Enterprise Centre in West Vancouver.

4.6. Conduct research on Caligus sea lice and its host dynamics and to better inform future management decisions and potential regulation.

Theme 5 — Alternate Technologies and Approaches

What We Heard and Council Observations

The council heard from the salmon farming industry and some participating First Nations that considerable improvements in technology have been made and incorporated into modern net-pen salmon farming operations and facilities. Many of these have come as a result of operational reviews and inquiries into industry operations, and include more efficient feeding and feed monitoring systems, and lighting systems.

The council was informed that there are a variety of closed containment technologies currently available including land-based recirculating aquaculture systems, advanced net-pen systems, near-shore floating containment and off-shore farming systems. The council heard that closed containment has the potential to mitigate the major environmental concerns associated with ocean-based net-pen salmon farms (e.g., transfer of pathogens and disease, sea lice, escapes, etc.)

The council observed that the financial viability of closed containment technologies remains a challenge. It was also pointed out in council discussions that the broader ecological impacts of land-based closed containment operations have not been fully investigated, including energy consumption, freshwater use, wastewater treatment and other aspects of operation.

The council also heard that Norway is implementing new land- and ocean-based technologies to increase salmon farm production and solve problems associated with sea lice and pathogens. For example, skirts being placed around the top of net-pens farms show promise of reducing sea lice infections. New licence categories are available as an incentive to develop and test these technologies.

All council members affirm the importance of providing advice to government on alternative technologies and approaches, and particularly on the feasibility of land-based salmon farming technologies as a future approach to industry development.

<u>Strategic Recommendation</u>

Provide incentives for the continued research, development and adoption of salmon farming technologies that reduce the risk to wild salmon, including land-based closed containment.

Immediate Recommended Actions

5.1. Establish financial incentives to invest in developing and implementing salmon farming technologies that reduce the risk to wild salmon and require their incorporation into siting and operational licences, as appropriate.

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. The study should explore a range of considerations including the technical, biological and economic feasibility of growing salmon in closed containment facilities, which locations would be suitable for these types of operations and the level of public support for closed containment relative to net-pen salmon farms.

Longer-Term Recommended Actions

5.3. Define a clear process for considering approval of a discharge licence during the site selection and approval process for land-based closed containment salmon farms.

Theme 6 —Transparency and Information Gaps

What We Heard and Observations

MAACFA heard there is a public perception that governments and salmon farming companies are unwilling to share all relevant information in a timely fashion. While government agencies and employees have the authority to collect farm samples and other data required to regulate the industry, this information is not routinely available to the public in raw or aggregated form. Non-government researchers have experienced difficulty in accessing fish farm samples and data for a variety of reasons. While steps have been taken recently to improve access to data, MAACFA heard that information in some instances is not easily accessible or provided in a timely manner and that both government and industry have roles to play in improving this situation.

The council received information on the Province's siting policy (Appendix 4) that indicates the results of public input opportunities on new tenure applications, such as open house meetings and response to advertisements, is made publicly available on the Province's website as part of the application documentation and "reasons for decision" on the application.

The provision of relevant information on salmon farming operations is essential to ensure proper management and to foster public trust in the industry. The council observed transparency and accessibility of fish health data from salmon farms remains a concern and is a source of mistrust and misunderstandings regarding aquaculture in B.C. In contrast, the council heard that Norway does not have this problem with salmon farming at 10-times the scale and over a similar geographic scale as B.C. in part because of coastal planning and community engagement. The council believes that a crucial first step to ensure proper management and to foster public trust in the industry provision of relevant information on salmon farming operations and wild fish populations both in a raw and an easily assimilated aggregated form.

All council members agree that increased transparency will have a positive effect on public trust.

Strategic Recommendations

Improve the timeliness and accessibility of information on finfish aquaculture.

Immediate Recommended Actions

6.1. Collaborate with DFO to develop a new, interactive and GIS-based website similar to the BarentsWatch site in Norway (https://www.barentswatch.no/en/) that provides ongoing information and updates on information collected and decisions made in association with new and replacement site tenure applications, site inspections, and farm operational permitting requiring provincial and federal government authorizations. Examples of information that should be available on the new website are provided in Appendix 7 (Theme 6).

6.2. Provide an annual update on the work of the science council (recommended action 4.2) describing the issues addressed by the council and advice provided, including progress on the state of science and future research priorities.

Longer-Term-Recommended Actions

6.3. As part of the regular review of aquaculture licence conditions, review public communication and data transparency activities, including the incorporation of new and emerging communications technologies, to increase public awareness and understanding.

6.0 Conclusions

When council members gathered for the first meeting in summer 2016, they knew this task would not be an easy one. Many other inquiries and reports have been commissioned on this general topic, and while these have resulted in changes they have not necessarily altered public perspectives or the spectrum of interests in this topic. While the industry has its detractors and environmental issues, it also has its supporters and its economic benefits to the province and to some coastal communities cannot be ignored.

Each member of the council brought their own significant knowledge and perspectives and the latter ranged widely. Despite this, discussions remained respectful and — even if perspectives diverged — it was recognized that the diversity of views from members and presenters brought balance to the task of addressing its terms of reference. The task itself was complex, and this should be no surprise to anyone observing the discussions on the topic of marine-based aquaculture continuing in the public domain.

All council members recognized there is a desire among many for a simple 'yes' or 'no' answer to the core questions in the terms of reference about the continuance of marine-based salmon aquaculture in B.C. Simple answers are rarely available to complex questions and this is the case for aquaculture. There is no agreement among council members about the level of risk to wild salmon stocks from net-pen salmon farming, something that should not be surprising given the range of perspectives that were brought to our table. There is consensus that changes are necessary and support for the recommendations with the understanding that for some members these are insufficient to fully address the harm posed by net pens and they favour a transition to land-based salmon farming. Yet other members consider the changes as a reasonable response to the risk posed by farms, allowing for the continuation of farming albeit in a manner that will further mitigate risk to wild salmon and engender greater public trust.

Our council appreciates being able to participate in the discussions on a matter of such importance to British Columbians and has done its work with a sincere desire to contribute to decisions related to finfish aquaculture in the province.

APPENDICES

Appendix 1 — Terms of Reference

Content provided by the Province of B.C.

Appendix 1 – Terms of Reference

Minister of Agriculture's Advisory Council on Finfish Aquaculture (MAACFA)

Background:

In July 2015 the Province announced that it will examine the rules and restrictions that guide the application and approval process to ensure that aquaculture operations are socially and ecologically sustainable and can co-exist with British Columbia's wild fishery resource. Specifically, the government will:

1. Strike a Minister of Agriculture's Advisory Council on Finfish Aquaculture that will include members from the aquaculture industry, non-governmental organizations and First Nations, as well as the Ministry of Agriculture and the Ministry of Forest, Lands and Natural Resource Operations.
2. Examine establishing a protocol for receiving advice from the Aquaculture Stewardship Council in regard to tenures for new aquaculture sites.
3. Examine the feasibility of improved microbe detection at aquaculture sites arising from the work being undertaken by Genome British Columbia in tandem with the other scientific evidence already available to the Province.

Recognizing the nature of the work to be undertaken by the Minister of Agriculture's Advisory Council on Finfish Aquaculture (MAACFA), the Province also stated in July 2015, that while these actions are being undertaken, the Province will not consider any further approvals for new salmon aquaculture tenures.

Scope and Purpose

MAACFA will provide strategic advice and policy guidance to the Minister of Agriculture (Minister) about the future of, and issuance of new Crown land tenures for, marine-based salmon aquaculture in B.C.

MAACFA's deliberations may include whether or not the Province should pursue development of marine-based salmon aquaculture in B.C. and if so, should yield recommendations to guide the application and approval process to ensure that aquaculture operations are socially and ecologically sustainable and can co-exist with British Columbia's wild fishery resource.

Minister of Agriculture's Advisory Council on Finfish Aquaculture, July 2015
Terms of Reference May 12/16 1

Principles

MAACFA will seek to provide a balanced and reasoned approach, mindful of divergent views, supported by staff and subject matter experts.

MAACFA is expected to reach consensus in providing recommendations. If not possible, MAACFA should reflect the different views of the members. MAACFA is not a decision-making body.

Operation

MAACFA may receive presentations from interested parties. MAAFCA may be asked to review and comment on proposals and will have the ability to request briefings from the industry or other experts.

Confidentiality

Conversations within MAACFA must be held in confidence. MAACFA members must not discuss or disclose the nature or content of these conversations with the public or the media as Cabinet confidentiality applies to advice and recommendations to be considered by a Minister or by the Executive Council (Cabinet). Similarly, written submissions and background materials prepared to inform MAACFA discussions must not be disclosed publically.

Membership

MAACFA will report directly to the Minister. MAACFA will have an appointed Chair and Vice-Chair to provide neutral and unencumbered leadership. The Ministry of Agriculture (AGRI) will provide the supporting secretariat. Officials from AGRI, the Ministry of Forests, Lands and Natural Resource Operations (FLNR) and the Ministry of Environment (ENV) will support the secretariat as required. MAACFA will be comprised of representatives from:

- First Nations (1 or more members, 1 alternate)
- Marine-based finfish aquaculture producers (1 or more members, 1 alternate)
- Non-governmental organizations (1 or more members, 1 alternate)
- Academia (1 or more members, 1 alternate)
- Marine planning (1 member, 1 alternate)
- Seafood industry/wild salmon harvest and processing (1 member, 1 alternate)
- The Deputy Minister of Agriculture or designate (1 ex officio member and advisor)

- The Deputy Minister of Forests, Lands and Natural Resource Operations or designate (1 ex officio member and advisor)

Fisheries and Oceans Canada (DFO) will participate as an observer and provide advice as appropriate.

In addition, other representatives with technical and academic expertise in the B.C. agrifoods and seafood sectors may be involved in short-term, task-focussed working groups.

Term

MAACFA will sunset 18 months after endorsement of the Terms of Reference. Immediately prior to dissolution, MAACFA will deliver a final report to the Minister.

Expenses

The Ministry will be responsible for travel costs, subject to government travel guidelines and requirements.

Secretariat Support

- James Mack, Assistant Deputy Minister, Ministry of Agriculture (AGRI), and Executive lead for the B.C. Seafood Secretariat
- Jim Russell, Director, Strategic Seafood Initiatives (AGRI)
- Officials from AGRI, FLNR and ENV as required.

The Ministry will provide meeting space, teleconferencing access and logistical organization.

Meeting schedule

MAACFA will report to the Minister on progress, within 100 days of establishment and subsequently as directed by the Minister.

Meetings will be convened at least once per quarter or more often as required.

Appendix 2 — Minister of Agriculture’s Advisory Council on Finfish Aquaculture (MAACFA)

Content provided by council members

Appendix 2 – MAACFA Membership

The following MAACFA members attended meetings on a regular basis.

Tony Allard

Chairman, Wild Salmon Forever

Tony Allard is a lawyer and investor from West Vancouver. His passion for wild Pacific salmon has motivated him to support those doing important salmon conservation work. As owner of Good Hope Cannery he supports Simon Fraser University (SFU) led salmon ecology research on Rivers Inlet sockeye salmon, "Take a Stand", an innovative program of SFU's Centre for Coastal Science and Management and the Wannock Chinook Protection Plan, which is building a hatchery at the head of Rivers Inlet. Good Hope Cannery has also donated several ecologically sensitive land parcels to the Nature Conservancy of Canada. He also supports the Pacific Salmon Foundation and the Salish Sea Marine Survival Project.

Keith Atleo

Operations Manager for the Ahousaht First Nation and the Ahous Business Corporation

John Bones (Vice-Chair)

Principal, JG Bones Consulting

John Bones has worked in land and marine policy and planning for over 35 years. He has been heavily involved throughout his working career in marine planning and policy initiatives on the B.C. coast, including those aimed at resolving issues associated with finfish aquaculture. He has worked with local and federal governments, as well as many First Nations and non-governmental organizations. He retired as a provincial government assistant deputy minister in 2009, and since then has continued work as an independent consultant, primarily in the areas of marine planning and policy.

Dr. Christina Burridge

Executive Director, BC Seafood Alliance

Dr. Christina Burridge is the executive director of the British Columbia Seafood Alliance, an umbrella association whose members represent about 90% of the value of B.C.'s wild seafood. Its mandate is to encourage sustainable, profitable fisheries on Canada's West Coast. She is closely involved with third-party programs to verify seafood sustainability, particularly the Marine Stewardship Council (MSC), and is a member of the MSC's Stakeholder Council. She is also the chair of the international Association of Sustainable Fisheries, representing fisheries in the MSC program and has worked for various Canadian fishing industry associations since 1988 and has been a member of numerous industry and government advisory groups, including the BC Pacific Salmon Forum, 2004-2009.

Bill Cranmer

President, Kuterra

Chief Bill Cranmer is a hereditary chief of the 'Namgis First Nation and former elected chief councillor from 1994 to 2014. College educated in Vancouver and a member of the Royal Air Force until 1959, he has been a positive force in the economic and cultural development of his community since his return to Alert Bay in 1978. He has served on the executive of both the Native Brotherhood of B.C. and the Native Fishing Association. He is currently President of Kuterra, a land-based recirculating aquaculture system, owned and operated by the 'Namgis First Nation.

Jeremy Dunn

Executive Director, BC Salmon Farmers Association

Jeremy Dunn has served as the executive director of the BC Salmon Farmers Association since March 2014 and has over 15 years of experience in communications, strategic planning, issues management and stakeholder relations. He has a great interest in aquaculture practices, scientific research and is an avid consumer of farm-raised salmon. Born and raised in B.C. and originally from Ucluelet on the west coast of Vancouver Island, he is proud to work with salmon farmers in B.C. who are raising some of the world's best fish.

Dr. Anthony Farrell

Canada Research Chair, Faculty of Land and Food Systems & Department of Zoology, University of British Columbia (UBC)

Dr. Anthony Farrell currently holds a Tier I Canada Research Chair (Fish Physiology, Culture and Conservation) at UBC where he researches the cardiorespiratory systems of fish and comparative animal physiology. He serves as assistant editor with the *J Fish Biology*, as the fish physiology section editor for *Aquaculture* and on the editorial board of *Canadian J Zoology*. He has published over 400 peer-reviewed articles in the scientific literature, co-edits a book series and has co-edited an *Encyclopedia of Fish Physiology*. He previously held faculty positions in Biology at Mount Allison University (1980-84) and Biological Sciences at Simon Fraser University (1984-2004).

Larry Greba

Director, Kitasoo Economic Development Corporation

Larry Greba has extensive experience and training in the field of wild fisheries management and community economic development. He has worked with 25 First Nations communities throughout British Columbia over the past 32 years primarily in fisheries enhancement, management, policy development, strategic planning and negotiation including shellfish and finfish aquaculture business development and environmental monitoring. He has worked closely with the Kitasoo/Xaixais Nation, Central Coast Indigenous Resources Authority, the First Nations Fisheries Council and the Coastal First Nations-Great Bear Initiative, and has represented the interests of many of these organizations on a myriad of boards and committees and has developed and serves as a director for several Kitasoo Band businesses.

Richard Harry

President, Aboriginal Aquaculture Association

Saya Masso

Natural Resource Director, Tla-o-qui-aht First Nation

Saya Masso is a member of the Tla-o-qui-aht First Nation and is currently their Natural Resource Director. He has a B.A. in economics and a master's degree in Indigenous Governance. He has been involved in the development of wild and cultured salmon resources in the Tla-o-qui-aht First Nations traditional territory for many years. In this capacity he has completed several land use plans and has been key in implementing a Guardian/Watchmen program for Tla-o-qui-aht.

Dr. Donald Noakes

Dean, Faculty of Science and Technology, Vancouver Island University

Dr. Donald Noakes is currently the Dean of the Faculty of Science and Technology at Vancouver Island University. He has been actively involved in research on Pacific salmon and interactions between wild and farmed salmon for 30 years. His career includes 19 years working for Fisheries and Oceans Canada and teaching and academic administration appointments at Thompson Rivers University (Kamloops) and Vancouver Island University (Nanaimo).

Dr. Brian Riddell

President and CEO, Pacific Salmon Foundation

Dr. Brian Riddell was a fishery scientist in the Department of Fisheries and Oceans for 30 years where he worked extensively on the assessment and management of wild Pacific salmon and has been associated with the development of salmon aquaculture since its very beginning in B.C. He is now the President/CEO of the Pacific Salmon Foundation in Vancouver B.C. and project leader, with Dr. K. Miller Saunders, of the Strategic Salmon Health Initiative that is currently researching microbes in all B.C. salmons and the potential impact of pathogens on the productivity of Pacific salmon.

Lee Spahan

Chief, Coldwater First Nation

Paul Sprout (Chair)

B.C. Commissioner, Pacific Salmon Commission

Paul Sprout works as a fisheries management consultant and is a director on the Pacific Salmon Foundation and a commissioner on the Canada-US Pacific Salmon Treaty. He has extensive experience in fisheries policy and management and during a 34-year career with the Department of Fisheries and Oceans held numerous positions, ranging from fisheries management biologist to associate assistant deputy minister resource management. He retired as the regional director general for the Pacific region in 2010. He has a strong interest and background in applying collaborative approaches in finding solutions to the challenges of sustainably managing fisheries.

John Werring

Senior Science and Policy Advisor, David Suzuki Foundation

John Werring received his master's of science degree in animal resource ecology from the University of British Columbia in 1986. He is a registered professional biologist and a member in good standing of the College of Applied Biology of B.C. He worked as an environmental consultant on major resource development projects throughout North and South America from 1984 to 1992 before joining the environmental not-for-profit sector in B.C. since 1992. He is currently senior science and policy Advisor to the David Suzuki Foundation based in Vancouver. He has been active on issues related to the environmental impacts of open net-pen fish farming since 2000.

Ex Officio Members:

Tom Ethier, *Assistant Deputy Minister, Resource Stewardship Division, B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development*

Sharon Hadway, *Regional Executive Director, West Coast Operations, B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development*

Wes Shoemaker, *Deputy Minister, B.C. Ministry of Agriculture*

Charles Short*, Executive Director, Strategic Projects, Regional Operations Division — Coast Area, B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development*

Craig Sutherland*, Assistant Deputy Minister, Regional Operations — Coast Area, Ministry of Forests, Lands, Natural Resource Operations and Rural Development*

Note: Derek Sturko attended MAACFA meetings as ex-officio member (B.C. Ministry of Agriculture) until mid-2017.

Fisheries and Oceans Canada (Observers):

Rebecca Reid, *Regional Director General, Fisheries and Oceans Canada (DFO)*

Or alternate **Andrew Thomson** — *Regional Director of Fisheries Management Branch, Fisheries and Oceans Canada (DFO)*

MAACFA Secretariat:

James Mack, B.C. Ministry of Agriculture

David Travia, B.C. Ministry of Agriculture

Appendix 3 — Overview of Finfish Aquaculture in British Columbia

Content reviewed and endorsed by council

Appendix 3 – Overview of Finfish Aquaculture in British Columbia

Evolution of Finfish Aquaculture

Salmon farming began in B.C in the early 1970s with the cultivation of both Chinook and coho salmon. During the 1980s there was a rapid increase in the number of farms and a shift to predominantly Atlantic salmon. By 1988, 101 different salmon-farming companies were operating in British Columbia. However, the industry as a whole was in its infancy, and techniques were largely ad hoc and evolved quickly. In the 1990s, industry consolidation began and by 1997, there were 79 active farms operated by 16 salmon-farming companies. Rearing techniques continued to evolve.

The geographical location of salmon farms along the B.C. coast has changed over the years. The industry began on the Sunshine Coast. Later, operators relocated and expanded to the North Coast, North eastern and western coasts of Vancouver Island, the Discovery Islands, and the Broughton Archipelago.

Most salmon farms are net-pen operations in the marine environment. They are currently located around Vancouver Island and the South Central coast, and one company operates in the Central Coast near Klemtu (see Figure 1 below.) The exceptions are: Kuterra LP's closed-containment, land-based Atlantic salmon farm established in 2010 by 'Namgis First Nation and operating on a site south of Port McNeill; Westcoast Fish Culture's steelhead salmon in lake-based farms where steelhead salmon are raised in floating semi-closed containment and net-pens; and Golden Eagle Aquaculture — previously operated by Swift Aquaculture — that raises coho in a land-based facility in Agassiz. The Kuterra and Golden Eagle facilities raise salmon on land for their full life cycle, while 19 land-based salmon farms raise fish for half of their life cycle for transfer to marine net pens for full grow-out.

For information on the location of currently operating and active sites, see:

http://www.pac.dfo-mpo.gc.ca/aquaculture/index-eng.html

The introduction of salmon farming and its rapid growth generated new economic benefits in rural parts of B.C.'s coast but, like other new industries, also generated a number of concerns. Over the past 30 years these have included impact of siting on adjacent uses (noise, visual intrusion, property values, etc.), ecosystem impacts (waste and chemical discharges, disease and pathogen transfer), and genetic impacts due to escapes. While salmon farming practices and technologies have worked to mitigate these concerns, the location of some sites and the potential for impacts on wild salmon have continued to be a focus of controversy.

In the early days of industry development along the coast, net-pen aquaculture site applications were referred by the regulatory authorities to potentially affected First Nations with a request for a time-limited response. Most First Nations did not have the financial or technical capacity to properly review and comment, and as a result many of these early tenured farm sites were considered by First Nations as unwelcome in their traditional territories. Over time, government's First Nation consultation requirements became more stringent and the industry began to pursue working relationships with First Nations for proposed sites and for existing farms. At this time, most farm sites have support from some, if not all First Nations who claim rights in a tenured area, and there are 20 operating agreements covering approximately 78% of the industry's total production. Other First Nations, both local and elsewhere on the coast and in the B.C. Interior, continue to be opposed to the farms.

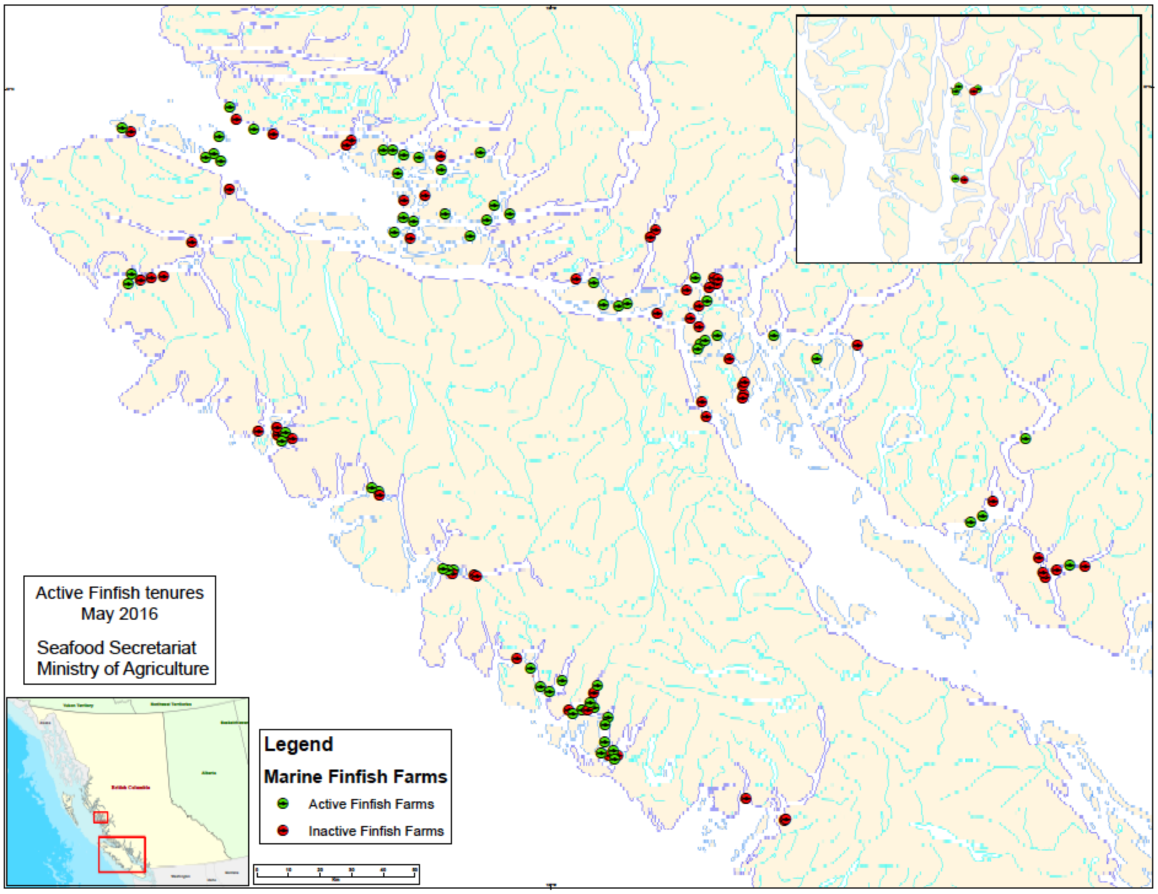
Current Farm Activity

The industry in British Columbia produces about 90,000 metric tonnes of farmed salmon annually, representing about 60% of Canada's production and 3% to 4% of the global production. The major producers worldwide are: Norway (1.2 million metric tonnes), Chile (500,000 metric tonnes), UK (150,000 metric tonnes) and Canada (120,000 metric tonnes). Farm-raised salmon is British Columbia's highest valued seafood product and second highest valued agricultural product behind dairy. About 70% of the harvest is exported, primarily to the USA (85% of exports).

Currently there are 120 ocean-based finfish aquaculture farms in B.C. and four companies account for the majority of the production of farm-raised salmon. Two are headquartered in Norway, one is owned by Japanese interests, and all are raising Atlantic salmon. The fourth is a Canadian company that raises Chinook salmon. Collectively, these companies hold 113 aquaculture site tenures for raising salmon (some locations have two sets of tenures due to changes made to the initial tenure with respect to how the site is placed). Typically, 60 to 70 sites are actively producing fish at any one time.

Both the federal and provincial governments have imposed temporary limits on the expansion of salmon farms in B.C. The federal Department of Fisheries and Oceans (DFO), in response to a Cohen Commission recommendation, has placed a limit on the number of salmon farming operations in the Discovery Island area until September 2020. Similarly, the Province of B.C. stated it has no intention of issuing new tenures or further expanding tenures for net-pen salmon farms in the Discovery Islands until at least September 2020. B.C. also placed a moratorium on salmon aquaculture on the North Coast in 2008 (north of Klemtu). Further, the provincial government has deferred consideration of any more approvals for new salmon aquaculture tenures while MAACFA deliberations are taking place.

Figure 1. Map of Active and Inactive Marine Salmon Farm Tenures, May 2016.



Finfish Aquaculture and Pacific Wild Salmon

Pacific wild salmon are an integral part of the marine environment, which is a significant component of the quality of life enjoyed by residents of British Columbia. Pacific salmon are a ‘key stone’ species for B.C.’s ecosystems and have been designated an official symbol of B.C. indicative of the importance that British Columbians place on their ecological, cultural and economic significance. Pacific salmon are vital to the culture, well being and livelihood of B.C.'s First Nations and wild salmon populations are often considered as indicators of overall ecosystem and wildlife health.

Commercial and recreational fisheries are based on the wild salmon resource and make a substantial contribution to the B.C. economy. According to a report *Economic Impacts of Pacific Salmon Fisheries* prepared in 2017 for the Pacific Salmon Commission, over the period 2012 to 2015, the combined contribution of the commercial and recreational sectors averaged US$1,364 million in Output, US$850 million in Gross Domestic Product, US$485 million in Labour Income and 12,400 fulltime equivalent jobs to the Canadian economy.

Currently, the primary concern about fish farms relates to the potential impact of pathogens transferring from farmed to Pacific wild salmon. The public discussion in B.C. about the potential detrimental impact of salmon farming on wild Pacific salmon includes reference to the experience in Norway, Scotland and Chile. B.C. is unique among these countries in that most of its salmon farms raise an introduced or non-native salmon species. In contrast, Chile has no endemic salmon populations. Since the vast majority of net-pen salmon farming is conducted in southern B.C. (Figure 1), the exposure of wild salmon populations to net-pen salmon farms is inevitable in this area at some geographic scale.

As previously noted, salmon farming practices in B.C. have evolved considerably since its beginnings over 30 years ago. Improved technology has led to advances such as higher quality, more sustainable fish foods that place less pressure on marine resources, automated feeding and surveillance systems that minimize food waste, fish health innovations such as vaccinations against common pathogens that may affect farmed salmon, and improved containment structures that have substantially reduced farmed salmon escapements.

Currently, 100% of the B.C. farms raising Atlantic salmon are certified to the Global Aquaculture Alliance's Best Aquaculture Practices standard, and B.C. is home to North America's only producer of certified Organic Chinook salmon. Farmers raising Atlantic salmon have committed to be 100% certified by the Aquaculture Stewardship Council (ASC) salmon standard by 2020. To date, over 40% of active production of Atlantic salmon is certified to the ASC standard.

Net-pen farmed salmon are currently vaccinated to protect against six diseases occurring naturally in the Pacific marine environment. The development of vaccines helps to lessen the need for the use of antibiotics and as a result, antibiotic treatments have been in decline. Antibiotic treatments are an important part of animal and human welfare, and are similarly used in aquaculture only to treat for illness in sick fish. These antibiotics are available only through prescription by a licensed veterinarian.

In terms of sea lice management, the regulatory threshold set by DFO is three sea lice (*L. salmonis*) per salmon. If this number is exceeded on a farm between March 1 and June 30, the farm is currently required to initiate a management response that can include harvesting fish (to reduce the total number of sea lice) or therapeutic treatment of salmon. The number of wild, out-migrating juvenile salmon carrying a sea louse varies considerably year by year and by geographic location. Returning salmon, carrying sea lice from their ocean migration, have been known to become a source of sea lice in the autumn months, and annual trends in the rise and fall of sea lice numbers on net-pen farm salmon are predictable.

Major investments have been made by fish farms to use recirculating aquaculture system (RAS) technology, a more sustainable method for producing high quality smolts. RAS recirculates 98% of water, greatly reducing water consumption, optimizing production and improving freshwater use and discharge.

To better understand the marine environment, and particularly wild salmon and interactions between wild and farmed salmon, the BC Salmon Farmers Association developed the Marine Environmental Research Program (MERP), which committed $1.5 million to fund competitive research between 2015 and 2020 to address one or more of the following four key research priorities:

1. Understanding endemic pathogens in wild and farm-raised salmon and their transfer mechanisms.
2. Understanding wild Pacific salmon migration and the factors that affect migration.
3. Understanding the interaction between salmon farms and the environment and investigating potential impacts while developing mitigations as appropriate.
4. Creating an improved and more accessible fish health data and reporting system.

Some council members note that the improvements in environmental performance have resulted in the Monterey Bay Aquarium's Seafood Watch program now listing B.C. farm-raised Atlantic salmon as a "good alternative" for sustainable seafood. The improved rating is reportedly due to an increase in independent, transparent, peer-reviewed data on the subject of disease transfer between farmed Atlantic salmon and wild salmon populations in B.C. There were also improvements to the effluent, habitat, escapes and introduced species criteria. B.C. is the only such region in the world to have this distinction for its entire Atlantic salmon production. However, the assertion of improved environmental performance by B.C. farms is disputed by some members noting that the statement is misleading, and that the Pacific Salmon Foundation, which collected some of the data used in the performance evaluation, believes that accreditation was premature.

Economic, Social and Community Perspectives

Salmon farming has become an important source of employment for First Nations people in B.C. Aboriginal people represent about 30% of the labour force of the four largest farming companies who operate the majority of farms in B.C. versus 5% of the population of B.C. (based the 2012 Aboriginal Peoples Survey, Statistics Canada).

In addition to the direct income and employment generated by salmon farming, the industry makes an important contribution to many coastal communities such as Klemtu, Port Hardy, Tofino/Ucluelet, and Campbell River. These communities have benefitted from diversification of the local economy, a stable increase to tax revenue, the growth of secondary service industries (e.g., administration, equipment and supplies) and support for numerous community groups.

A recently released independent economic analysis of the salmon aquaculture industry in British Columbia identified an increase of 37% over the past three years in its value to the province, resulting in the creation of over 1,600 jobs. Overall, farming and processing of salmon in 2016 resulted in over $1.5 billion towards the B.C. economy. The total GDP generated by the B.C. farm-raised salmon industry increased 36% from $411.5 million to $557.8 million. The total employment generated by the B.C. farm-raised salmon industry increased 33% from 4,977 to 6,610 full-time equivalents. The government taxes generated by the B.C. farm-raised salmon industry increased 39% from $62.0 to $86.1 million (MNP Report September 2017 — *Economic Impacts of the B.C. Farm-Raised Salmon Industry – 2017* Update.

The full value chain in the salmon aquaculture sector has turned record high prices over much of the past three years into an unprecedented investment in the sector including farming infrastructure, process plants, land-based hatcheries, and marine vessels, an increase in business performance, as well as an increase in environmental and biological performance.

Appendix 4 — Finfish Aquaculture Management in British Columbia

Content reviewed and endorsed by council

Appendix 4 – Finfish Aquaculture Management in British Columbia

Current Aquaculture Roles and Responsibilities

Across Canada, governance of aquaculture activities varies from one jurisdiction to another. The federal and provincial governments share regulatory authority over aquaculture and bi-lateral agreements clarify the roles and responsibilities of these levels of government. The federal and provincial governments are legally obligated to consult with First Nations on all aquaculture management and development decisions that could impact their rights. In British Columbia, First Nations and aquaculture companies play important roles in the governance of aquaculture. As well municipal government zoning regulations can also affect where aquaculture facilities can be located.

A summary of roles and responsibilities follows:

Federal Government

Fisheries and Oceans Canada (DFO) has the lead federal role in managing Canada's marine fisheries and safeguarding its waters.

Since assuming primary responsibility for regulation and management of B.C. aquaculture activities in December 2010, DFO has managed the aquaculture industry in B.C. through the *Pacific Aquaculture Regulations,* (PAR) and, since 2015, the *Aquaculture Activities Regulations* (AAR).

The PAR established a licensing regime and legal framework consistent with DFO's mandate to manage fisheries and protect wild fish and fish habitat. The AAR came into force in 2015 and further clarifies conditions under which aquaculture operators deposit therapeutants, pesticides and organic matter, along with monitoring and reporting responsibilities.

Key activities under DFO's B.C. Aquaculture Regulatory Program (BCARP) include licensing, review of applications, consultations with First Nations and stakeholders, environmental monitoring, fish health management and public reporting.

Transport Canada is responsible for ensuring the public's safe navigation of Canada's waters without obstruction through the *Navigation Protection Act*. Health Canada and the Canadian Food Inspection Agency (CFIA) both play a role in overseeing aquatic animal health measures (disease prevention, detection and control, feed, medication, and biologics) and supporting DFO in ensuring healthy and productive aquatic ecosystems. The CFIA is also responsible for overseeing use of veterinary drugs administered to food-producing animals and determining whether proposed pesticides can be used safely and will be effective for their intended use.

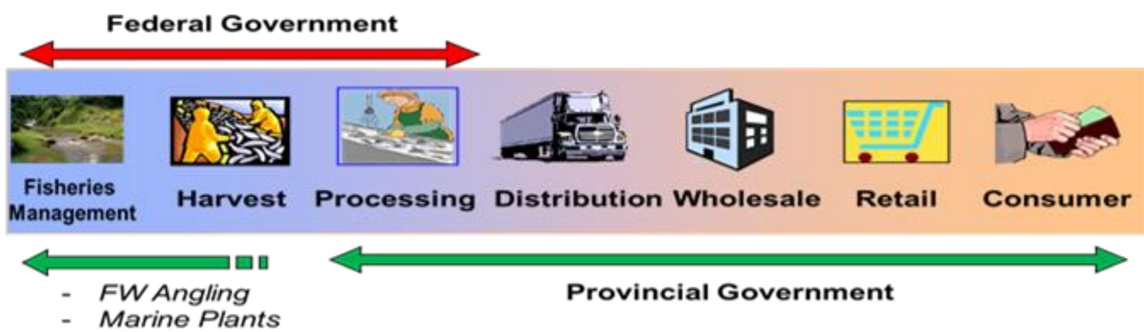
Provincial Government

The provincial government’s regulatory responsibilities and activities associated with finfish aquaculture management relate primarily to issuing Crown tenures (primarily leases or licences of occupation) that allow salmon farms to operate in provincially owned foreshore, nearshore and inland waters and conduct related activities on shore.

Key provincial responsibilities by ministry are summarized in the table below:

Ministry of Agriculture	• B.C. lead for seafood industry development • B.C. lead for strategic aquaculture policy • Aquaculture industry specialist on staff • Maintains Animal Health Laboratory in Abbotsford
Ministry of Forests Lands and Natural Resource Operations and Rural Economic Development	• Issue tenures authorizing the use of the land, foreshore and marine areas for finfish and shellfish aquaculture (*Land Act*) • Issue freshwater licences (*Water Sustainability Act*). • Marine use planning
Ministry of Environment and Climate Change Strategy	• Issues permits for sewage discharge (*Environmental Management Act*) • Issue permits for pesticide use (*Integrated Pest Management Act*)

Figure 2. Schematic Diagram of Federal and B.C. Roles and Responsibilities



Provincial Government Tenure Process Information

To assist with deliberations council posed questions to the provincial ministries involved in aquaculture regarding current policies and practices. Responses received are outlined in accordance with the questions asked:

Is the requirement for community meeting on a proposed finfish site a policy or a best practice/advice to applicant?

Standard requirements for *Land Act* applications:

New *Land Act* applications are:

- Advertised in a local paper for two consecutive weeks.
- Posted on the provincial Applications and Reasons for Decision website.
- Physically staked with a notice of application for disposition posted on site.

The public can submit comments through an online form, or directly to the Section Head, Aquaculture, for a period of 60 days.

The Operational Land Use Policy for Aquaculture outlines the advertising/notification requirements that go beyond a standard *Land Act* application as follows:

> "All new finfish applications will require public consultation which will most often be conducted via an open house session in a local community near the area under application. Where possible, the Authorizing Agency will coordinate the holding of such an open house with DFO."

While the statutory decision maker has the discretion to interpret this requirement, the practice in recent years has been consistent in conducting public open houses for new finfish applications.

There is some interpretation regarding what an appropriate location might be. For instance, early in 2015 an open house was conducted in Klemtu for two new sites in the area. The applicant was required to conduct an additional open house that was more accessible to the wider public; that open house was conducted using a web-based format.

Is the requirement specific on timing? Is it required before an application is accepted, or after it is accepted?

The open house does not become a requirement until the application is accepted for review. The province does not have the ability to enforce requirements without an application. In the case of new finfish applications, a Project Review Team (PRT) with membership from FLRNORD, DFO and Transport Canada conducts an initial screening of applications to determine completeness and whether there may be serious conflicts/showstoppers. Applications which pass this initial screening by the PRT are then advanced for full review by all three agencies in accordance with their mandates.

What is the requirement, if any, for the conducting of the meeting? Is there a requirement to advertise the meeting? Who runs the meeting? Is it required to be an open house or a meeting? Does the ministry send someone to be present?

The Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) provides a guidance document to finfish companies on open house requirements including the requirement to advertise, and general format of the open house. Usually staff from the regional office of FLNRORD and DFO attend the open house.

The applicant is required to bear the cost of the open house and generally organizes and conducts the meeting. Public comment forms are being provided to attendees and may be submitted to the applicant at the open house or directly to the ministry.

As an example, in early 2015 an open house was held and approximately 1300 comments were submitted directly to the ministry; another several hundred comments were submitted to the company directly and those were re-directed to the ministry.

The guidance document states:

> "Public comment forms should be provided for each application, and include provision for contact information.
>
> The public should be informed that all comments received will be forwarded to the Ministry of Forests, Lands and Natural Resource Operations (FLNR), Fisheries and Oceans Canada (DFO) and Transport Canada (TC).
>
> The comments form should provide the following disclosure to the public: *FLNR has advised that the information you provide may be subject to the following legislation: British Columbia Freedom of Information and Protection of Privacy Act (FOIPP Act); the federal Access to Information Act; and the federal Privacy Act. The information you submit is not considered to be confidential, unless it is subject to specific provisions contained within one or more of the above-noted Acts*."

What are the requirements for how is the public input is documented and collated? Who does that?

The public can submit comments:

- During the open house on comment forms which are then forwarded to FLNRORD.
- Through the provincial Applications and Reasons for Decision website;
- Directly to FLNRORD staff.
- Directly to the company.
- To DFO who then redirect comments to FLNRORD that pertain to the tenure application.

Ministry staff collate all comments and they are placed on file and become part of the public record. An overview and summary of all comments received is included in the land use report which is the document prepared by staff to present recommendations to the decision maker. Comments that pertain to a federal mandate, such as relate to DFO's or Transport Canada's mandates are summarized within the FLNR land use report and are also forwarded to the applicable agency.

How is the meeting information and results used in the review and adjudication process? Is the holding of the meeting sufficient to confirm public input has been addressed, or is there an expectation that the applicant alter any aspects of the siting application as a result of the documented input?

The open house is an opportunity for the public to review the proposal and submit any questions or suggestions to the proponent and/or the authorizing agencies; application packages are also available on the provincial Applications and Reasons for Decision web site. Many companies opt to provide additional information on their web pages.

The public comment period is kept open after the open house to allow time for the public to consider the information and submit comments.

The decision maker is looking to understand how an application may impact the interests of different individuals or stakeholder groups. The decision maker may choose to mitigate potential impacts in a number of ways, including but not limited to:

- The requirement for changes to the proposal including changes to the location or tenure area and shape.
- The addition of conditions to the tenure document.
- Additions to the management plan (e.g. a commercial tourism mitigation plan).
- Disallowing (rejecting) the application.

The decision maker owes an administrative duty of fairness to both the applicant and to parties that may be impacted by the application.

Can you confirm who or what body makes the final decision on the application? Is it the FLNRO authorization officer holding the file, or is it a joint body?

DFO, Transport Canada and FLNRORD make separate, independent decisions based on their respective legislative mandates. Best attempts are made to synchronize those decisions such that the applicant receives coordinated responses from the three agencies on their application.

For land tenure decisions, the minister of FLNRORD is the statutory decision maker named in the Land Act; however, many of the decisions in the Land Act are delegated to various positions within the FLNRORD organization. Typically, the delegated decision maker for aquaculture land tenures is a regional staff member within the ministry's regional operations division for the West Coast Natural Resource Region, either the resource manager, authorizations or the section head, aquaculture.

What is a tenure replacement?

Replacement tenure means a subsequent tenure agreement issued to the tenure holder for the same purpose and area. Replacements usually occur at the time of tenure expiry and are subject to a review being undertaken and a decision made under the Land Act.

What is the process for a company to request a finfish tenure renewal/replacement?

Application packages are requested from existing tenure holders with tenures within six months to one year from the expiry of the term.

The application packages include submission of information related to infrastructure, and provincial siting requirements as noted in Parts I, II and V of the harmonized aquaculture application form found here:

https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/crown-land-uses/aquaculture/pacific_marine_finfish_amendment_application.pdf

and an application fee (set in the Land Act Fee Regulation).

What factors are used in the determination to offer a renewal?

Once the application package is received, the information is reviewed by FLNRORD staff; consultation with First Nations is initiated; and the tenure is reviewed for diligent use and compliance with terms and conditions of the tenure.

FLNRORD staff review the tenure for conflicts with other land uses, and may carry out agency referrals if there are issues on file that trigger another agency's mandate. For example, an application may be referred to Transport Canada for concerns raised about navigation.

Consultation with First Nations is undertaken as per government's consultation guidelines, or any Strategic Engagement Agreement in place. Potential impacts to Aboriginal interests (rights & title) are assessed and the results of consultation inform the tenure decision.

Other replacement considerations include whether the existing tenure is in good standing, the development proposed in an existing management/development plan has been completed, and if there are other matters of public interest that need to be addressed, including any guidance that may have come into effect since the original tenure was issued, for example Marine Plan Partnership for the North Pacific Coast (MAPP). Additional information be may be requested from the tenure holder.

Public input on replacements

A public input or consultation process is not usually undertaken on replacement applications.

Where ministry staff are aware of a specific issue or concern or complaint regarding a specific tenure the opportunity exists to address this issue at the time of replacement. Usually this will take the form of a change to a management plan, or addition of a specific covenant (you must/you must not) in the tenure document.

In a more general sense, if a replacement decision is positive, a new tenure document is issued which captures the policy of the day. Modern day tenure agreements have stronger provisions such as environmental liability clauses and others to address matters in the public interest. For aquaculture, most comments that relate to environmental impacts tend to be fall within DFO's mandate.

Local government input on replacements

Since replacement decisions are regarding the continuation of an existing operation, local government and other agencies are not typically referred to except in rare cases where there is a known issue.

As tenure area and overall use do not change, there is usually not a lot that local government is able to comment on at the time of replacement. If zoning or bylaws have changed, the *Local Government Act* requires that existing uses are grandfathered.

Decision making

Decision makers consider all facts and findings that result from the review process.

If potential negative impacts associated with a decision to replace a tenure are identified, the decision maker may identify mitigation measures to be implemented either through tenure conditions, management plan addendums, or expressed commitments by the tenure holder (e.g. Impact Benefit Agreements).

Open House

As part of the review process under the Land Use Operational Policy — Aquaculture, all new finfish applications will require public consultation which will most often be conducted via an open house session in a local community near the area under application. The following guidelines are intended to assist applicants for planning an open house:

> **Government Agencies**
>
> Applicants should coordinate the open house session with Ministry of Forests Lands and Natural Operations (FLNRO) to ensure availability of staff to attend the meeting. While not a requirement, applicants are also strongly encouraged to contact Fisheries and Oceans Canada (DFO) and Transport Canada (TC) to determine if these agencies will be available to attend the meeting and respond to questions related to their respective mandates. In some cases, if an agency is not able to attend, a questionnaire may be provided for receiving public comments

Advertising

The open house should be advertised in local papers two to three weeks in advance of the meeting date.

The open house should be held in one or two communities near the location of the proposed facility, to ensure there is ample opportunity for the public to attend.

The open house should cover a timeframe that will help facilitate public attendance (ie 4:00 to 8:00pm).

Advertising Template

(Your Company Logo)

Notice of a Public Open House

Regarding a Proposed Finfish Aquaculture Site

Located Near (the general location of the proposal).

You are cordially invited to attend an open house hosted by (Your Company) at (the location of the meeting) from ____ p.m. to ____ p.m. on (the date of the meeting). Also in attendance will be representatives from the Ministry of Forests, Lands and Natural Resource Operations, (and/or any other agency attending). The purpose of the open house is to seek public comments on activities that may occur at or in the vicinity of the proposed finfish aquaculture facility located at (the specific location). (Your Company) has submitted an application to occupy Crown foreshore for the purpose of finfish aquaculture and the related works associated with that purpose.

This open house will be an opportunity for the public, interest groups and agencies to provide comments on other uses or activities that occur at the proposed application site.

It is also an important opportunity to share information regarding the geographical placement of the site and details of the proposed operation.

“We look forward to meeting with you on (the date of the event).

Setting up the Open House.”

A sign-in sheet is recommended.

Public comment forms should be provided for each application, and include provision for contact information.

The public should be informed that all comments received will be forwarded to the Ministry of Forests, Lands and Natural Resource Operations (FLNR), Fisheries and Oceans Canada (DFO) and Transport Canada (TC).

The comments form should provide the following disclosure to the public:

> "FLNR has advised that the information you provide may be subject to the following legislation: British Columbia *Freedom of Information and Protection of Privacy Act* (FOIPP Act); the federal *Access to Information Act*; and the federal *Privacy Act*. The information you submit is not considered to be confidential, unless it is subject to specific provisions contained within one or more of the above-noted Acts."

Consider providing an information package that the public can take away such as information about the application, where people can submit additional comments, information about your company, etc. Distributing accurate and adequate information is an essential step in ensuring that residents and stakeholders have the resources they need in order to provide meaningful input on a proposed aquaculture facility.

When hosting an open house, the format is variable and often uses various information stations; application package, fish health, anchoring, benthic, etc. This provides an opportunity for people to learn more about what you are proposing and also allows for discussion with one of your in-house experts.

Clearly identify the person that is in charge of hosting the meeting. You may wish to consider an experienced facilitator to help ensure a successful meeting.

In some situations, it may be advisable to consider having one session in a near-by community and a second session further away in a community that is more accessible.

As a best practice, take notes and forward any comments or concerns that are raised to FLNR0, DFO, and TC.

First Nations

Although First Nations in B.C. do not have management authorities over aquaculture development specified in provincial and federal legislation or regulations, they carry the stewardship and management responsibilities and obligations for marine resources handed down through successive generations of governing people through chieftainships of specific areas that includes decision making and traditional laws on how lands, waters and resources are used. These stewardship and management responsibilities are particularly relevant given that the majority of First Nations on the coast of B.C. have not signed treaties and, from their perspective, have never ceded or yielded aboriginal rights or title to their marine traditional territories.

As a consequence, the provincial government must refer all applications for finfish aquaculture tenures to the First Nation(s) in whose territory the site is located. The primary role of the First Nation is then to review to application and respond with an indication of whether or not aboriginal rights would be affected. These requirements are central to the United Nations Declaration of Rights of Indigenous Peoples (UNDRIP) and call for free, prior and informed consent by First Nations for activities such as salmon farming. The application of UNDRIP is currently being reviewed for adoption by both the federal and provincial governments. In some instances, First Nations have taken actions to evict salmon farms from their territories that are operating without their approval or agreement. In other instances, First Nations collaborate directly with salmon farming companies, through formal written agreements to raise salmon on their territory and have an active role in the management and governance practices.

Aquaculture Industry

The aquaculture industry in B.C. participates in DFO's consultative processes, including the Finfish Aquaculture Industry Advisory Panel. This committee reviews management plans on a regular basis and provides advice and recommendations to DFO on the management of finfish aquaculture in B.C.

All salmon farmers in B.C. are licenced and obliged to comply with regulations, prescribed standards and protocols stipulating conditions for the operation of all aquaculture facilities.

Salmon farming companies in B.C. have been proactive in working with First Nations. Currently they have 20 economic and social partnerships with coastal First Nations and 78% of B.C.'s annual production of farm-raised salmon is harvested from areas covered by agreements with First Nations.

Appendix 5 — Summary of Presentations Made to Council

Content reviewed and endorsed by council

Appendix 5 – Summary of Presentations

To help gain a thorough understanding of relevant matters, MAACFA received 20 presentations on a variety of topics related to finfish aquaculture and wild fish conservation and restoration. These presentations covered a range of perspectives, including those of some First Nations, environmental organizations, scientists, veterinarians, a Vancouver Island municipality and the finfish aquaculture industry association.

Individuals who made presentations to MAACFA along with their affiliation are shown below along a brief summary of each individual presentation.

First Nations

- Richard Hardy - First Nations Fisheries Council
- Larry Greba - Kitasoo/Xaixais First Nation
- Saya Masso - Tla-o-qui-aht First Nation
- Chief Bob Chamberlin - First Nation Wild Salmon Alliance
- Keith Atleo, Wally Samuel and Laurie Jensen – Ahousaht First Nation and Cermaq Canada

Richard Hardy made a presentation on behalf of the First Nations Fisheries Council (FNFC). The FNFC has an Aquaculture Coordinating Committee comprised of members drawn from 14 regions covering the entire province of B.C. The role of FNFC and the Aquaculture Coordination Committee is not to approve or condone the aquaculture industry in B.C. but to ensure that First Nations rights and title are considered in policies, legislation and management decisions. His presentation noted the complexity of the current regulatory environment and that First Nations are seeking a greater role in all aspects of aquaculture including science, development of policy and legislation, and environmental monitoring. He also noted that inland First Nations are interested in exploring fresh water aquaculture for FSC and economic purposes.

Larry Greba made a presentation on behalf of the Kitasoo/Xaixais First Nation. This presentation was a case study describing the Kitasoo/Xaixais First Nation involvement in aquaculture, including community priorities, best practices and environmental measures. The First Nations established principles and priorities that were used to guide their approach to aquaculture, including control, environmental sustainability, employment/capacity and royalties. A high level of effort was dedicated to identifying appropriate salmon farm sites. The community holds the tenures to salmon farm sites while the company (Marine Harvest) holds the aquaculture licence. The environmental measures included in the Kitasoo/Xaixais protocol agreement include the following: one company model, no first generation smolts, access to all information, notification of treatments and community environmental monitoring. Salmon farming makes an important contribution to the local economy, accounting for 51% of the community's employment in 2015 and generating $1.9 million in wages.

Saya Masso made a presentation describing the Tla-o-qui-aht First Nation's role in managing aquaculture within their territories. The presentation outlined the evolution of the Nation's relationship with aquaculture companies in their territory from the late 1990s to the present, which served to emphasize the importance of First Nation's control of the guiding principles used in farming salmon on their territory (e.g., no use of night lights)**.** The Tla-o-qui-aht First Nation now has a protocol agreement for the Chinook salmon farming operations in their territory ensuring that lands, waters, and watersheds are developed in a manner that reflects respect for First Nations governance and for progressive environmental stewardship. The council noted that their protocol was developed largely in advance of a permit/licence application.

Chief Bob Chamberlin made a presentation on behalf of the First Nation Wild Salmon Alliance. The presentation highlighted concerns that the federal and provincial government consultations with First Nations related to aquaculture were inadequate and that the level of scientific information on the impacts of salmon farms on wild salmon was insufficient. In addition, the presentation stressed the importance of First Nations' rights and the role that First Nations should play related to all activities that occur within their territories.

Keith Atleo, Wally Samuel and Laurie Jensen made a presentation that described the partnership and protocol agreement involving the Ahousaht First Nation and Cermaq Canada. The Ahousaht-Cermaq partnership evolved after the company initially approached the Ahousaht First Nation in a respectful manner. In 2002, the agreement between the two parties was reflected in a one-page agreement that was subsequently renewed and improved and the current agreement is 34 pages. The presentation noted that it took time, perseverance and trust to make a partnership. A number of other factors were identified as contributing to the partnership, including respect, understanding, commitment, cooperation and mutual benefits. The current protocol does not extinguish, abrogate or deny any aboriginal rights and title of the Ahousaht First Nation, respects claims for constitutionally-protected rights and title in salmon farming areas and respects historic and contemporary uses and stewardship of land, water and resources.

Scientists and Veterinarians

- Dr. Craig Orr — Watershed Watch Salmon Society
- Dr. Stewart Johnson — DFO
- Dr. Brian Riddell — Pacific Salmon Foundation
- Dr. Craig Stephen[a] — Canadian Wildlife Health Cooperative
- Dr. Kristi Miller — DFO
- Dr. Jane Pritchard[b] — Province of B.C.
- Dr. Gary Marty[b] — Province of B.C.

- Dr. Marvin Rosenau — BCIT
- Dr. Larry Dill — SFU
- Dr. Ann-Magnhild Solås — Norwegian Institute of Food, Fisheries and Aquaculture Research (Nofima) - Visiting Postdoctoral Fellow UBC

[a] Doctor of Veterinarian Medicine and Ph.D.

[b] Doctor of Veterinarian Medicine

Dr. Craig Orr made a presentation on behalf of the Watershed Watch Salmon Society. This presentation focused on sea lice and included data from B.C. and other jurisdictions. The presentation noted that migrating B.C. juvenile salmon face greater exposure to sea lice as a result of salmon farms (i.e., migratory allopatry negated) and that salmon farms amplify sea lice on sockeye salmon. While the impact of sea lice on wild B.C. salmon populations is unknown, the presentation noted a crash in pink salmon adult returns to the Broughton Archipelago in 2002 following high levels of juveniles being infected with sea lice in 2001, that Caligus sea lice can impair feeding/growth and increase predation risk of sockeye salmon, sea lice may transmit up food webs, and a coordinated sea lice treatment approach on salmon farms may improve the survival of wild salmon. The presentation raised questions regarding the scientific basis for the sea lice treatment triggers currently in place (three per fish) and whether sea lice are developing resistance to SLICE©. The presentation concluded with a description of resilience thinking, noting factors including the ability to avoid or bounce back from a disturbance, crisis or change.

Dr. Stewart Johnson (DFO) made a presentation on fish health, in particular disease and risks associated with salmon farming. The presentation identified information needed to understand the risk of pathogen-disease transmission between wild and farmed finfish, including generic information on: (a) migratory pathways of wild salmon and the duration of their residency in the vicinity of fish farms; (b) prevalence of pathogens and diseases within wild and farmed populations; and, (c) knowledge of the infectious dose necessary to cause disease.

Dr. Brian Riddell made a presentation on B.C.'s Pacific salmon resource, ecology, and pressures. The presentation outlined the distribution of Pacific salmon, the complexity of the salmon genetics within B.C. with regard to networks of salmon populations and their production, and the need for management of interactions between wild, hatchery, and aquaculture salmonids (since at present this cannot be avoided). This presentation stated that of all the salmon aquaculture-producing countries of the world, it should be expected that British Columbia would have the greatest concern for potential impacts on wild salmon given the diversity and wide spread geographic distribution of our salmon, and their high ecological and human importance (culturally and economically). He also pointed out that Justice Cohen noted that "global climate change" was the 'elephant in the room' in terms of wild salmon production and future effects.

Dr. Craig Stephen made two presentations with the first describing risk and risk management in terms of a continuum and explaining that a person's perception of risk is heavily influenced by their beliefs as opposed to simply being based on science. The presentation identified health as a unifying paradigm while noting that there is no definition of health in legislation or literature. Issues related to aquaculture and health were described as complex problems that will not be solved by usual reductionist approaches. The presentation suggested that leaders need to change the narrative regarding aquaculture and that such a change would require shifting the focus: from risk to protecting health; from resolving conflict to collaborating on solutions; and, from resolving risks to supporting decisions. Finally, the presentation suggested that it is important to identify a shared vision of success that is linked to health.

His second presentation outlined a harm reduction model that is intended to reduce the harmful consequences of risky activities. The presentation described harm reduction principles and new forms of collaboration that encourage action in the face of debate. Dr. Stephen emphasized the importance of trust in fostering collaboration among individuals and organizations involved in harm reduction efforts. He noted that the harm reduction model has been applied in the context of human health issues, including drug use in the Vancouver's Downtown East Side but has not been used to date to address natural resource issues. Dr. Stephen explained the potential benefits of using harm reduction to address the interaction between salmon farms and wild salmon. He also noted that harm reduction is not a replacement of efforts to eliminate risks but rather it can provide a transparent way to look at social and ecological trade-offs in a collaborative manner.

Dr. Kristi Miller made a presentation that described the results of work to date under the Strategic Salmon Health Initiative (SSHI) that focuses on discovering the pathogens and potential diseases that may undermine the productivity and performance of B.C. salmon, their evolutionary history, and the potential role of exchanges between wild and cultured salmon. The presentation described a number of challenges with understanding disease impacts on wild populations and noted that sub-lethal effects of infection may be more detrimental in wild than cultured fish and that piscine reovirus (PRV) is highly prevalent in farmed fish (approximately 70% of farm audit samples) while PRV was detected, but not common, in migratory smolts. The presentation noted that the PRV-associated diseases HSMI and jaundice are present on B.C. salmon farms but many other viral diseases are absent (e.g., ISAv, IPNv, Omv, Sav, PMCv, and ASPv). Dr. Miller confirmed that her lab's SSHI work has identified three novel viruses which merit more study.

Dr. Jane Pritchard, B.C.'s Chief Veterinary Officer, made a presentation that described the Plant and Animal Health Branch of the organization that she leads. The presentation highlighted both the high level of qualifications of professional staff and the quality of the work performed in their laboratory. Quotes from the most recent American Association of Veterinary Laboratory Diagnosticians (AAVLD) audit indicate that the laboratory: "... *has a mature quality system that is universally supported by both technical and administrative staff… There was evidence of a mature and fully implemented quality system."* These comments are based on an audit that determines that every result is verified, every piece of equipment is properly calibrated, every procedure is validated, and every member of the team is qualified. The laboratory is one of only three in Canada with dual accreditation AAVLD and Standards Council of Canada and ISO 17025 and the only one not associated with a veterinary college.

Dr. Gary Marty made a presentation that noted diseases and parasites are natural and common in wild salmon and that the biology of disease transfer operates in a similar manner for salmon as it does for people. The following quote from the Cohen Commission was presented: "*In summary, I have concluded that net-pen salmon farming in the Discovery Islands poses a risk of serious harm to Fraser River sockeye through the transfer of diseases and pathogens.*" The presentation noted that diseases do transfer between wild and farm salmon and noted that less than 1% of farm fish die per year of significant disease (compared with 3% per day which is the normal death rate of wild juvenile salmon) and that diseases that do not spread inside the farm will spread even less outside the farm. The presentation concluded with the statement that: "*Salmon farm diseases pose no more than minimal risk of serious harm to migrating wild salmon populations*." Dr. Marty confirmed that the heart lesions he has been finding in fish samples for a decade or more and Dr. Miller's findings of HSMI in similar samples are really the same disease. The only difference is that they each call the disease by a different name.

Dr. Marvin Rosenau made a presentation, described as a scoping exercise, which examined the following question: "were there any declines associated with fish stocks that migrate through areas of fish farms potentially causing mortality of the juvenile migrants and through the time-frame of fish farm expansion in southwestern British Columbia?" Information was presented that compared trends in the survival, catch and returns of adult salmon to various river systems. The comparisons included a number of wild and enhanced salmon species, including sockeye, Chinook, coho and steelhead. Based on a linear regression analysis of complex trends observed, the presentation concluded that where juvenile salmonids migrate through areas of concentrated fish farms in southwestern British Columbia, there have been large-scale collapses over many different selected species and populations.

Dr. Larry Dill made a presentation entitled "Why Open Net Pens Present a Risk to Wild Salmon" which focused on two sources of risk — (i) sea lice and (ii) other pathogens, including viruses (PRV, ISAV, IHNV, SLV). He noted that lice move from salmon net pens to wild salmon, and that negative impacts of lice on individual salmon are well documented. Many of these effects are indirect, including reduced competitive ability and increased vulnerability to predation. Population effects are harder to confirm, but there is strong evidence that lice have negatively impacted Broughton Archipelago pink and coho populations, and an experiment has provided strong evidence of the effect of sea lice on Atlantic salmon populations in Norway. With respect to other pathogens and viruses, he noted that PRV is on salmon farms where it can and does cause HSMI, it can be transferred to wild fish, and PRV is implicated in the heavy pre-spawning mortality of Fraser sockeye. He referred to evidence that aquaculture facilities provide ideal environments for the evolution of pathogen virulence. On the other hand, while resistance of lice to SLICE© is evolving in Europe, there is little evidence of this happening in B.C. at this time.

Dr. Dill suggested two specific actions. First, that Caligus sea lice and its host dynamics, especially the potential involvement of herring, requires further study. Second, that it behooves governments at all levels to invoke the Precautionary Principle and work to transition the industry from ocean-based open net pens to closed land-based production systems as soon as possible.

Dr. Ann-Magnhild Solås made a presentation on Aquaculture Governance and Marine Spatial Planning in Norway. She explained that salmon farming is controversial in Norway, though not to the same extent as in B.C. Many of their concerns are similar to those associated with salmon farming in B.C., in particular sea lice, disease transfer, escapes and competition for sea space. Sea lice are estimated to kill about 10% (about 50,000) of Norway's wild salmon population annually. Aquaculture governance in Norway places heavy emphasis on spatial planning and municipalities hold the key to coastal area access. Through the Sami Parliament, Norway's indigenous people have the right to object to spatial plans on questions concerning Sami culture, commerce and social life. Norway has a high level of transparency related to the aquaculture industry, including timely salmon farming information available online, and a science council that reports annually on the state of the wild salmon populations and effects of salmon farming on wild salmon. The national government's objective is to increase production significantly and is providing financial support and licensing incentives to develop more environmentally sustainable technologies such as closed systems in fjords, open pens further offshore and land-based systems.

Community

- Mayor Hank Bood —District of Port Hardy

Mayor Hank Bood made a presentation of behalf of the District of Port Hardy. This presentation described the evolution of the salmon farming industry on northern Vancouver Island and the contribution it makes to the local economy. Salmon farming provided alternative income and employment in the district when the mine closed. The mayor noted that salmon farmers support numerous community groups and recently Marine Harvest committed $250,000 toward construction of a proposed multiplex facility in Port Hardy. Mayor Bood acknowledged there is a degree of opposition to aquaculture in some north island communities, including First Nations communities, but noted salmon farming is strongly supported by residents of Port Hardy. Mayor Bood attributed this support to the positive impact that salmon farming has had on Port Hardy.

Aquaculture Industry and Certification

- Jeremy Dunn — BC Salmon Farmers Association
- Michiel Fransen — Aquaculture Stewardship Council (ASC)

- Garry Ullstrom and Gary Robinson — KUTERRA

Jeremy Dunn made a presentation on behalf of the BC Salmon Farmers Association (BCSFA). The BCSFA represents 52 organizations, including the four major salmon farming companies. BCSFA represents companies who operate 118 of 120 ocean farms in B.C. The BCSFA member companies also operate land-based farms at 20 sites. Salmon farming companies have been proactive in working with First Nations. Currently they have 20 economic and social partnerships with coastal First Nations and 78% B.C.'s annual production of farm-raised salmon is harvested from areas covered by agreements with First Nations. The presentation noted that Canada produces 120,000 metric tonnes of farmed salmon of which about 60% comes from B.C. (about 90,000 metric tonnes) representing between 3 to 4% of the global supply. Farm-raised salmon is the province's highest valued seafood product and second highest valued agricultural product behind dairy. About 70% of the harvest is exported, primarily to the USA (85% of exports go to the U.S.)

Michiel Fransen presented an overview of the Aquaculture Stewardship Council (ASC). He explained that the ASC vision is "*A world where aquaculture plays a major role in supplying food and social benefits for mankind whilst minimizing negative impacts on the environment*". The ASC certification process involves a transparent standard setting process and a third-party certification system that is science based and metric driven. The ASC standards are being revised and will move from seven standards to a single farm standard with provision for species-specific requirements. In addition, it is expected that the new standard will include an area approach thereby addressing potential farm-to-farm interactions. Through the certification process, the ASC encourages responsible aquaculture practices while acknowledging it is not in a position to ensure sustainability. To date, the ASC has certified more than 450 farms in 38 countries with a total production of more than 1 million tonnes annually.

The ASC Salmon Standard (7.2 Respect for indigenous and aboriginal cultures and traditional territories) has never resulted in a B.C. salmon farm being denied certification (i.e., meeting the standard requires a form of consultation — not the consent of the First Nation).

Garry Ullstrom and Gary Robinson made a presentation that described the KUTERRA salmon farm that operates as a land-based recirculating aquaculture system (RAS) and the future growth potential for this technology. KUTERRA's mission is to test the technical, biological and economic feasibility of growing salmon in a RAS. The presentation noted that to date the technical and biological feasibility has been proven while the economic feasibility and environmental sustainability is highly dependent on the scale of operation. The future success of KUTERRA's salmon farm is linked to establishing partnerships with new investors, upgrading the current facility and increasing the scale of the operation. The presentation included a number of recommendations to encourage the expansion of land-based aquaculture in British Columbia.

Appendix 6 – Description of Harm Reduction and Risk and Council's Observations on Risk Sources

Content reviewed and endorsed by council

Appendix 6 – Description of Harm Reduction and Risk and Council's Observations on Risk Sources

The council's recommendations presented in this report are intended to provide a continuum of care by addressing both known existing harms to wild salmon and the risk of future harms. While council members have strong divergent views on the biological risks associated with salmon farming, in particular on the risk of widespread pathogen and disease transfer, all members agree that actions are needed now to reduce the harmful consequences of social and scientific controversy associated with net-pen salmon farming. A brief description of harm reduction and risk follows.

What is Harm Reduction?

Harm reduction is aimed at reducing the more immediate harmful consequences of an activity through pragmatic, realistic programs feasible under current conditions. It is most commonly associated with public health actions against persistent problems such as addiction and homelessness. Its inclusion in this report reflects the council's desire to inspire new tactics to overcome entrenched perspectives and inaction to ensure progress on sustaining wild salmon populations, irrespective of member's diverse perspectives.

Harm reduction promotes relationships, structures and processes to make incremental gains towards safer, more sustainable situations. It could work to reduce the negative social consequences of salmon farming without necessarily relying on elimination of the salmon farming. Harm reduction emphasizes strengths, possibilities, and opportunities to reduce harms and in this situation its focus is on social discontent, which arguably is self-evident to all interests, and it develops a hierarchy of achievable small wins that builds trust and collaboration, despite differing opinions and uncertain evidence.

The council's interest in harm reduction recommendations offer a new process to mitigate the social conflict harms associated with salmon farming and foster collective actions. The council recognizes a number of current impediments to harm reduction actions that constrain collective actions, including the following:

> There is no agreed threshold for acceptable harm or acceptable risk. MAACFA recognizes that, while there is no consensus on the acceptable level of risks or harms, there is a shared vision of sustaining wild salmon within a healthy ecosystem while recognizing the interdependence and importance of salmon to communities in B.C. This forms the basis for harm reduction cooperation.
>
> Some of the members observed that in a prior court case related to this matter, Judge Rennie speaks of "a risk of serious or irreversible harm" being the "essence" of the precautionary principle (P.27 [57], while Judge Cohen speaks of "a risk of serious harm',

but in neither instance are the adjectives quantified. Judge Cohen adds that regarding the risk of serious harm to Fraser River sockeye through the transfer of diseases and pathogens: “The full extent and likelihood of that harm cannot be determined because of scientific unknowns. Precautionary measures should focus on filling the knowledge gaps and enabling DFO to adapt mitigation measures to new scientific information. (volume 3, page 25).”

Past recommendations have been predicated on fundamental changes in knowledge, governance, social conditions, or regulations, few of which have come to fruition: The pace of scientific, social, and political change can be slow and many environmental hazards cannot be quickly eliminated. Little attention in past reports has focused on steps that can be taken “where we are now” rather than “where we want to go.” As such, current harms prevail and actions on shared goals are delayed due to challenges in securing the required new knowledge, regulations, or technology.

Recommendations, regulations, and research tend to focus on a sub-set of harmful substances or actions in a piecemeal fashion rather than seeing harms as multi-dimensional and interconnected. Social and biological harms are interconnected in complex ways that create opportunities and constraints for risk management. The past emphasis on finding consensus on biological harms without accounting for social harms has reduced chances of finding common pathways or opportunities to reduce or eliminate risks and harms.

Past recommendations have generally not focused on new forms of strategic collaboration that allow actions on shared values while debate remains on the scope and mechanisms of harm. There have been some specific efforts but no systematic approach to developing governance or collaborative frameworks to allow action on shared goals while scientific uncertainty and differing values exist.

Harm Reduction Principles

The principles of harm reduction are well suited to B.C. marine salmon farming:

Principle 1 — The goal of harm reduction is to create an enabling environment for collaborative and cooperative actions. Harm reduction seeks multidisciplinary pathways to remove barriers to implementing knowledge. It actively works to engage a diversity of players in finding solutions throughout the chain of causation and does not blame or judge the participants. Resources are dedicated to fostering conditions that will allow collaboration despite differences in opinion and perspectives.

Principle 2 — Harm reduction is pragmatic. Harm reduction seeks incremental gains that are feasible within the current circumstances and state of knowledge. It recognizes that negotiations and compromises are needed to foster actions and invests in identifying a hierarchy of achievable steps that, taken one at a time, can lead to healthier, safer, more sustainable and more accepted situations.

Principle 3 — Harm reduction acts on where we are now rather than relying on the creation of a preferred future before acting. Harm reduction does not let disagreements on some harms or risks delay collaboration on other harms for which there is agreement. It prioritizes actions that support ongoing development of safer practices under the current conditions while not ruling out the longer-term goal of prohibitions or restrictions on certain activities.

Principle 4 — Harm reduction is inclusive and contextual. Harm reduction emphasizes bottom-up planning tailored to local conditions but respectful of wider societal expectations and knowledge. It recognizes that no one approach works for everyone in all situations. Harm reduction emphasizes action plans that adapt recommendations and actions to specific social and ecological circumstances to produce incremental gains that can be built on over. Individuals, agencies, companies, and communities affected by or affecting harms and risks need to be involved in co-creating harm reduction strategies. For example, the current siting process for aquaculture is more of a top-down rather than a bottom-up, harm-reducing process.

Principle 5 — Harm reduction is integrative. Ensuring salmon sustainability and health is a complex and multifaceted undertaking. Most attention has been placed on biological harms associated with salmon aquaculture, for which there is no consensus on their magnitude or likelihood. Throughout deliberations, council heard of many social harms linked to this industry including impositions on aboriginal rights, conflicts within communities, political liabilities and damage to the industry's reputation. The harm reduction approach recognizes that complex, multi-faceted phenomena require a continuum of actions that look at biological and social harms as well as the interdependencies between them.

The council recognizes that harm reduction solutions need to be built on trust but there is pervasive pessimism that entrenched positions and past conflicts will prevent future collaboration. Trust can be built by addressing simple short-term objectives. The council heard about a growing number of examples where collaboration between First Nations and salmon farming companies has reduced conflict and resulted in mutual benefits. The council encourages public agencies, communities, and the industry to learn from and build on these successes and rely more on bottom-up approaches with local communities.

What is Risk?

There are many definitions of risk and the specific use of the term often varies depending on the context — e.g., health, safety, economic, environmental, information security, etc. The

International Organization for Standardization definition of risk is the "effect of uncertainty on objectives." In this definition, uncertainties include the likelihood of an event occurring and its effect; and uncertainties caused by ambiguity or lack of information.

Risk management strategies typically focus on the likelihood of an event occurring and severity of the impact if it does occur. A 2003 Privy Council of Canada document, *A Framework for the Application of Precaution in Science-Based Decision Making about Risk*, makes the following points about resolving scientific uncertainty and applying precaution:

- To resolve scientific uncertainty, research and scientific monitoring are key parts of the application process.
- The responsibility for producing scientific data may shift among governments, industry, or other proponents.
- Where scientific information is inconclusive, decisions still have to be made to meet society's expectations about enhancing living standards and addressing the potential risks.

There are three separate factors that determine if risk is high or low. They are:

Probability – What is the probability of a hazardous event occurring?

Exposure – What is the duration an individual is near the hazard, and what is the intensity of the hazard.

Consequence – What would happen if the hazard harms the individual and cumulatively to the population?

What Sources of Risk Are We Aware Of?

Council members noted that since the inception of net-pen salmon farming in B.C. risk to wild Pacific salmon have been associated with:

Contaminants and waste — A concern that net-pen salmon farms discharge harmful contaminants and waste into the environment, including, antibiotics, pesticides and fecal material.

Atlantic salmon escapes — A concern that Atlantic salmon that escape from net pen farms will contaminate the genetics of wild salmon, compete for food and habitat, and prey on juvenile wild salmon.

Sea lice — A concern that sea lice from net-pen salmon farms reduce the survival of migrating wild juvenile salmon.

> *Infectious Disease* — A concern that net pen salmon farms promote infectious disease outbreaks and the causative agent may spread to migrating wild salmon, causing debilitating disease in wild populations.

The council noted that the intensity of public discussion about specific concerns related to B.C. salmon farming has changed over the past 30 years. In particular, concerns that waste and chemical discharges from salmon farms are having a significant detrimental impact on wild salmon have diminished. Similarly, concerns about Atlantic salmon escapes from net-pen fish farms have also decreased according to reports published by government and industry. Currently, the primary concerns about fish farms are the transmission of pathogens between farmed and wild salmon, especially if a pathogen is not endemic to British Columbia, and the impact of sea lice from salmon farms on juvenile wild Pacific salmon.

Given the complex nature of pathogens and disease, there is a high level of uncertainty and knowledge gaps related to the likelihood of transmission between farmed salmon and wild salmon, and the potential effects associated with such transfers. Of particular concern is the risk of a catastrophic decline in wild salmon populations if a highly virulent pathogen (e.g., an exotic pathogen or mutation of a virus) was to be transferred to wild salmon.

In addition to concerns that salmon farms may have a detrimental impact on migrating wild salmon and other wild fish living in close proximity to the farm, the council heard about other factors affecting wild salmon. In particular, climate change is creating oceanic and freshwater environments that are less predictable and may be generally less favourable to both wild and farmed salmon. As well, some wild salmon stocks are at low levels due to a variety of ongoing factors, including logging, urban development, industrial pollution, fishing, etc. which makes them less resilient to withstanding additional pressures.

Appendix 7 — Harm Reduction and Risk Topics

Content reviewed and substantially endorsed by council

Appendix 7 – Harm Reduction and Risk Topics

This appendix contains additional information on each of the six themes presented in Section 5.0 of the MAACFA final report.

The content in this appendix is substantially endorsed by council members. However, council member Dr. Tony Farrell has expressed a concern with aspects of subsection Theme 4 which in his opinion do not provide a balanced view of scientific knowledge on the subject. Dr. Farrell is supportive of the remaining themes of the appendix.

Theme 1 — Salmon Farm Locations

MAACFA discussed a number of issues related to the location of salmon farms in the marine environment and the operating conditions on those farms (equipment and operating practices).

Climate change is a major concern for B.C. salmon farmers when considering both siting and day-to-day operations. There is a concern that sites, which were once optimal, will not be as water temperatures become increasingly warmer, and conditions become drier, impacting salinity via decreasing snow pack and altered rainfall patterns.

Climate change has an impact not only directly on farm-raised salmon through the environment, but indirectly through its effects on increasing toxic algal blooms, shifting wild species ranges, and potentially changing pathogen regimes — for example, types of pathogens and virulence. Increased frequency and intensity of storm events associated with changing weather patterns are also a concern for salmon farmers.

In addition to climate change effects, the council heard that some farms are located along the migratory route of major wild salmon populations, raising concerns related to pathogen transfers. It noted that not all salmon farms are located in optimal sites with good flushing ability (i.e., where strong currents minimize potential negative impacts of harmful contaminants and wastes into the local environment, such as fecal material, excess feed and therapeutants). Council heard that the density or number of salmon farms within a geographic area may increase the risk to wild salmon (i.e., the duration and intensity of being exposed to a potential hazard) and result in cumulative environmental effects related to a requirement for flushing that exceeds the natural capacity for exchange of seawater.

In terms of regulatory requirements, the application process for siting is shared by several provincial and federal government departments[1], includes consultation with First Nations, consideration of nearby salmon bearing streams, park reserves, water use, waste management,

[1] BC Finfish Aquaculture Siting Application - http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/crown-land-uses/aquaculture/pacific_marine_finfish_new_site_application.pdf

transport implications and navigational markings, production type and levels, local wild fish and habitat, and a number of management plans that must be in place prior to the site beginning operation. These cover requirements for inventory plans, containment, health management, escape prevention and marine mammal interactions.

DFO regulates day-to-day operations of salmon farms in B.C. Conditions of licence[2] consider: production and inventory, fish transfers, containment array requirements, fish health and associated records, sea lice monitoring, sea lice health and mortality reporting, escape prevention, reporting and response, incidental catch, management of marine mammal interactions, protection of fish habitat, operation of vessels, use of lights, and other administrative matters.

It was noted that some farms have been moved from locations that were considered problematic and that a variety of improvements have been made to equipment and operating conditions to prevent escapes, reduce the amount of feed settling below net pens and eliminate impacts that resulted from the use of copper netting. MAACFA heard presentations from several First Nations describing how they have influenced salmon farming operations they are involved in, including the number of net pens, the location of net pens, density and species farmed. Protocol agreements involving First Nations and salmon farming companies have been used to formalize these arrangements.

Theme 2 — Aboriginal Rights and Title

First Nations' support is a major factor in determining acceptability and viability of net-pen aquaculture siting and operation. Most First Nations on the coast do not have treaties. To avoid infringement of aboriginal rights and title in their territories, First Nations must be consulted and accommodated with respect to salmon aquaculture siting and operations.

The ability to address First Nations rights and title is complicated, in some areas, by the existence of shared traditional territories, in which two or more First Nations assert ownership and stewardship responsibilities, and may be in various stages of treaty or reconciliation negotiations with B.C. and Canada. In some locations at present, farms are operating with participation and support of one Nation while being actively opposed by others.

Salmon farming companies in B.C. have been proactive in working with First Nations. Currently they have 20 economic and social partnerships with coastal First Nations and 78% of B.C.'s annual production of farm-raised salmon is harvested from areas covered by agreements with First Nations. Major industry participants now have developed their own collective guidelines

[2] DFO Finfish Conditions of Licence: http://www.pac.dfo-mpo.gc.ca/aquaculture/licence-permis/docs/licence-cond-permis-mar/col-cdp-eng.html

that include the need for First Nations support prior to application for any new net cage aquaculture site tenure or license.

First Nations' communities are an important source of traditional knowledge and a growing body of scientific information on marine ecosystems, as well as on conditions and trends. Many First Nations, however, have human resource and financial capacity limitations in terms of reviewing and responding to farm site tenure applications, and in participating in other aspects of farm management.

Even with an overall increase in First Nations capacity to engage in the salmon farm assessment process, there remains a lack of formal, cooperative processes on net pen aquaculture site and operational license applications involving the B.C. and Canada governments with First Nations, at either an aggregate or individual Nation level, despite constant prompting by the courts.

First Nations on the Pacific coast and in the B.C. Interior regions, First Nations now seek to develop these processes for a greater role in the monitoring, enforcement, science and research of all fisheries including both wild and farmed salmon in their territories and ultimately the development of true co-management structures and joint authority with other governments that includes the review and adjudication of salmon farm site tenures and licences.

Shared decision making with provincial and federal governments is a specific objective of First Nations, as reflected in recent shared marine planning work and in fisheries and ocean protection management discussions. The courts now frequently recognize this self-determination. In addition to Canada's domestic laws and policies, the United Nations Declaration of Rights of Indigenous Peoples (UNDRIP) includes reference to free, prior and informed consent by First Nations. The application of UNDRIP is currently being reviewed by both B.C. and federal governments. Its application would clearly have relevance to government siting decisions for net pen aquaculture.

Theme 3 — Marine Planning and Community Engagement

A variety of perspectives are held in and amongst different coastal communities on the effects of net-pen aquaculture and the salmon farming industry. Salmon farming has become an important source of direct income and employment for some coastal communities (including First Nation communities), and makes important contributions to individual and community well being. However, many communities and members of beneficiary communities continue to oppose the industry. Given the long history of public debate and continued controversy surrounding net pen aquaculture siting, increased attention to community perspectives and effects is required. The development of new forms of collaboration to address diverse community perspectives is consistent with a "harm reduction" approach.

Information provided by B.C. on new and replacement salmon farm site tenure applications suggests some inconsistency with respect to engagement of public, communities, local governments and stakeholders and an assumption that public trust aspects of siting decisions need only be addressed at the time of new tenure applications. The existing B.C. government process includes the referral of a new site application to the affected local government entity (usually a regional district) for comment, as well as other affected government agencies. Salmon farm site applications require public open house meetings, in addition to public comment opportunities provided through normal website posting, land staking and local newspaper advertising. These requirements are necessitated only after an application is accepted for processing as a result of a joint screening by a B.C./ DFO/ Transport Canada Project Review Team. A guidance document provided by FLNRORD identifies advertising, meeting conduct and means of documenting feedback, which is to be forwarded to the Project Review Team. FLNRORD staff collates all comments and places them on file as part of the public record. An overview of and summary of all comments is included in the land use report prepared by staff for decision-making purposes. The information received may be used to alter the site application, include additional tenure provisions, require alteration to a management plan, or disallow the new application. FLNRORD makes the decision on a new tenure application, and makes best efforts to synchronize its decision with those of federal departments.

The process for replacement (renewal) of site tenures to the same company is initiated by FLNRORD, which requests a replacement tenure application six months to one year in advance of expiry of the site tenure. New information, including new policy and known public complaints, is factored into the replacement decision, but does not include any requirement for public or community input. Replacement applications are not referred to local government for comments. This approach is standard policy for all land tenures issued by B.C.

A number of standing advisory committees exist along the coast to provide input on federal and provincial resource management activities, including DFO committees on fisheries and aquaculture, as well as those associated with B.C.-First Nation marine spatial planning processes. These standing committees generally include community and stakeholder representation. Expanding the mandate and financial support to relevant advisory structures would increase public trust opportunities for salmon aquaculture activities and help reduce conflicts, where sites and operations have addressed First Nations rights and title obligations and levels of involvement in the project proposals.

The council heard that aquaculture governance in Norway places heavy emphasis on spatial planning, and that local government spatial plans determine whether or not a farm site will be considered. The B.C. government has recently made the reinvigoration/modernization of planning as one of its top priorities, suggesting an acknowledgement of the important role that spatial planning can play in resolution of conflicts in B.C. and the development of public trust for future use of public lands. Interestingly, four marine spatial plans have recently (2015) been jointly developed by B.C. and First Nation aggregate organizations, covering the area from

Campbell River to Haida Gwaii. These plans specify whether or not, where, and under what conditions, aquaculture site applications are to be accepted by the B.C. government for processing. The plan development and implementation processes were inclusive of local government and stakeholder representatives, utilizing sub-regional advisory committees. These plans, however, are considered by B.C. only as policy guidance for consideration in a site application decision, despite being an important governance tool and an expression of social and political acceptability. These plans would benefit from reinforcement by various regulatory tools at government's disposal to enforce the plan direction on aquaculture.

Other coastal plans that provided similar direction to government for tenure applications were completed by B.C. in the 1990s by B.C. with input from some local First Nations, and are in need of updating. There are also areas of the coast that have no such spatial plans available.

Theme 4 — Pathogens and Disease

MAACFA heard several presentations from scientists and veterinarians on pathogens and diseases in wild and farmed salmon in B.C. The risk of pathogen transfer between wild and farmed salmon is perhaps the most controversial topic facing the salmon farming industry in British Columbia and worldwide, and the sometimes, conflicting presentations the council heard have led to or reinforced differing perspectives on some key issues.

Pathogens are infectious agents (bacteria, viruses and parasites) that have the potential to cause disease. A disease is a particular abnormal condition that affects part or all of an organism associated with specific symptoms and signs, and typically associated with specific pathogens. The expression of a disease (the clinical signs) can also vary depending on an individual's environmental condition. Clearly, this confounds our understanding of disease in farmed, hatchery, and wild Pacific salmon. The latter is referred to as the context for a disease.

Diagnosis of specific diseases involves identifying the causative agent, if known, and the clinical signs that are associated with the disease (i.e., expression of effects in various tissues and/or behaviour). Unfortunately, some clinical signs may be similar for a number of diseases so definitive diagnostics is done by individuals with specialized technical training in fish pathology.

Disease is not an inevitable outcome of exposure to pathogens. A fish's immune system may result in no infection at all or a carrier state may exist in fish where there is infection but no overt clinical signs and symptoms (development) of the disease. Host susceptibility and environmental conditions are important factors in determining whether individuals will develop a disease following exposure to a pathogen and if that disease will ultimately spread to the general population. Transmission of pathogens can be between individuals (horizontal) or within an individual (e.g., vertically to their offspring), but these characteristics are highly variable among pathogens. Likewise, the susceptibility of salmon to infection by a given pathogen varies considerably among species.

In response to infection, fish may exhibit sub-lethal effects, such as changes in physiological processes, reduced feeding and growth, and altered behaviors; each of which can also be affected by environmental conditions. Such effects are detectable in salmon farms and laboratory experiments but detecting sub-lethal effects in wild salmon is seldom possible given that they are free-ranging and not observable at any given time. Further, wild fish suffering from sub-lethal effects of disease are likely prone to predation and removed from the population.

Fishes native to our local waters have developed immune responses to endemic pathogens but different species can have variable responses to pathogens and environmental conditions can influence the efficacy of their response. Atlantic salmon while domesticated for aquaculture in B.C., are a non-native species and have not developed natural immunities leaving them susceptible to a variety of pathogens. Atlantic salmon farmed in B.C. currently receive vaccination for six diseases (IHNv, furunculosis, bacterial kidney disease, enteric redmouth and two strains of vibrio bacteria). Vaccines are used to stimulate the immune system to try to prevent and/or modulate infection so that bacteria and virus replication is greatly diminished, thereby protecting the host from contracting the disease. Indirectly, vaccinations could also provide protection for fish in the surrounding environment by minimizing the number of virus or bacteria that are shed to the environment. Vaccines used on B.C. salmon farms have had mixed results. Vaccines used for IHNv and variants of vibrio and furunculosis have worked well while the efficacy for bacterial kidney disease vaccines has been less, although incidents of BKD on Atlantic salmon farms remain rare. But it should be recognized that while vaccines can be efficacious at one time, pathogens are living organisms that can mutate to the point where the vaccine will no longer work and/or the pathogens will develop resistance to vaccines. Science in this area continues to evolve and global efforts continue to ensure vaccine efficacy and develop new defenses against pathogens to further reduce the use of antibiotics.

For diseases that are vertically transmitted such as bacterial kidney disease and IHN, brood-stock screening has been an effective health management tool in salmon enhancement facilities and the salmon farming industry. Fish found to be carriers of a pathogen are not used as brood-stock, so as to stop infection between generations and potentially to select for fish that may have a greater resistance to pathogens of concern.

Transmission of pathogens may also be through other marine fish species, not only involving Pacific salmon species. Pacific Herring (*Clupea pallasii*) are likely the best-documented example involving two viral diseases known to be infectious in salmonids (Erythrocytic necrosis virus and Viral Haemorrhagic Septicaemia virus). Viral pathogens may also be transmitted via sea lice.

Fish health on salmon farms is monitored by farm company veterinarians and by the government. Members of the BCSFA that rear Atlantic salmon have developed a viral disease management plan which establishes biosecurity protocols to limit potential pathogen transfer and allows for a quick industry-wide response if a virus of concern is detected in B.C. salmon farms. The plan facilitates an area-based response to control and manage the spread of a viral infection to protect farmed and wild salmon. In addition, salmon farmers participate in sampling programs run by the Canadian Food Inspection Agency and DFO to assist with viral monitoring.

Strategic Salmon Health Initiative (SSHI)

In 2013, Genome British Columbia, the Pacific Salmon Foundation and Fisheries and Oceans Canada (DFO Science Branch) embarked on a research partnership to discover the microbes present in salmon in British Columbia that may be undermining the productivity of Pacific salmon. The project has been conducting epidemiological assessments to explore the transmission and historical presence of detected microbes, with key focus on microbes that are suspected globally to cause disease in salmon. Researchers are applying genomic technology to identify and verify which microbes are presently carried by B.C.'s wild and cultured fish (in federal hatcheries and in aquaculture), and assess their potential effect on fish.

The Strategic Salmon Health Initiative (SSHI) was initiated for a few reasons, the primary one being the variable survival of juvenile salmon during their early ocean migration. Infectious disease may contribute to salmon mortality, but not enough is known about the distribution or impact of disease agents in wild Pacific salmon populations in their natural habitats. Most of the current knowledge about any potential for effect has been derived from observations of cultured fish (both in enhancement hatcheries and net pen aquaculture). To address this, SSHI is using a four-phased program to discover the microbes present in Pacific salmon that may reduce the productivity of our Pacific salmon.

In *Phase 1*, the primary goal was to obtain collections of wild, hatchery and aquaculture salmonids from southern B.C. This phase provided a tissue inventory for assessment of microbes carried both by wild and cultured salmon in B.C. (approximately 30,000 samples, collected and historical archives). The first steps also included the development of a stakeholder consultation process (Public Interest Panel) that will provide input to the information needs, public engagement and communications, and ways to integrate research on microbes and disease on B.C. salmon. Phase 1 sample collection also included sampling Atlantic salmon in four farms in the Discovery Islands and Johnston Strait under an agreement between SSHI participants and the BC Salmon Farmers Association. The agreement allowed sample collection during one entire production cycle in each farm. It was this sampling that revealed the presence of heart and skeletal muscle inflammation (HSMI) disease in one BC salmon farm (Di Cicco et al. 2017).

Phase 2 involves rigorous analysis of the tissues samples and has been subdivided.

- *Phase 2a* is complete and required the development and evaluation of a new and innovative research platform. This technology, the Fluidigm BioMark™ HD System, offers an ability to analyze samples on a scale never done before. The platform can analyze up to 90 individual fish simultaneously, screening for the presence of 45 microbes (pathogens) at once, and 2 to 3 arrays can be assessed per day. Extensive testing of this new platform was completed and accepted for application (Canadian Science Advisory Secretariat (CSAS), Science Advisory Report 2015/039; CSAS Research Advisory Rpt 2016/038).

- *Phase 2b* consists of the analyses and epidemiology studies. In addition to novel research using the Fluidigm technology, a portion of the samples collected for molecular monitoring also undergoes histopathology analyses and gene expression profiling to identify microbes most likely to associate with disease. DFO Audit samples from dying farmed fish are also analyzed to identify microbes associated with mortality of farmed salmon in B.C. This phase of sample analyses is continuing.

Phase 3 involves challenge studies that will focus on the microbes identified in Phase 2, with an emphasis on microbes that have not been extensively researched and/or are associated of pathological significance in salmon. Controlled rearing studies of pathogenicity through laboratory studies will elucidate potential routes of exchange (horizontal or vertical) within and between species. Phase 3 will begin towards the end of Phase 2 to expedite information needs on microbes that are newly discovered in B.C. salmon. Preparation of challenge facilities with appropriate controls for disease challenge work will be required and, at this time, is a significant limitation to progress in the SSHI study.

Phase 4 is the reporting of research and presentations to management agencies on the potential utility of methods developed and the application of outcomes to future monitoring. The culmination of the project will likely be in 2019/20 when data have been compiled and challenge studies completed.

How individuals view and understand issues associated with pathogens or diseases influences their perspective of risk to wild and farmed salmon. As noted in one of the presentations to the committee, health (of salmon) is a unifying paradigm that was cited more than 400 times in the Cohen Commission Report, more than 100 times in DFO's Wild Salmon Policy, and referred to routinely by the salmon farming industry which is required to produce mandatory health management plans for their farms. A common understanding about what constitutes health for both wild and farmed salmon would be an important starting point to develop a framework for the future management of these important resources. Pathogens and disease are part of nature and consequently a component of the health of both wild and farmed salmon that need to be recognized and managed as neither can be completely eliminated from wild or farmed fish.

To date, only endemic pathogens have been detected either at salmon farms or in wild Pacific salmon based on monitoring and surveys by several groups and organizations. Specifically, some exotic pathogens of special concern such as ISAv (Infectious Salmon Anemia virus), IPNv (Infectious Pancreatic Necrosis virus), Omv (*Oncorhynchus Masu* Herpesvirus), Sav (Salmon Alphavirus), PMCv (Piscine Myocarditis Virus), and ASPv (Atlantic Salmon Paramyxovirus) have not been detected.

The notable exception to the viruses described above is Piscine Reovirus (PRV) that is now widespread in B.C.'s salmon farms and has variable incidence in B.C.'s wild salmon. PRV was first confirmed in Pacific salmon by Kibenge et al. (2013) following detections of PRV in trout in Cultus Lake by the BC Animal Health Centre (Chilliwack Progress. July 23, 2012). These authors reported that all Canadian PRV isolate samples belonged to the Norwegian PRV sub-group 1a and had greater than 98.1% sequence identity with the Norwegian strain; and they estimated that this PRV strain was introduced to BC in the mid to late 2000's[3] (the authors did not offer any explanation for the introduction of PRV to BC). However, Marty et al. (2015)[4] reported PRV in paraffin blocks of BC salmon sampled in the early 2000s, with weaker evidence possibly as early as 1992. PRV is now acknowledged to be widespread in BC salmon farms but has much lower incidence in wild Pacific salmon (0 to 20%). But recently, Morton et al. (2017) reported higher incidence of PRV in wild salmon in proximity to salmon farming regions of BC and much lower in regions furthest from farms. And, in samples of Pacific salmon from Washington State and Alaska, Purcell et al. (2018) reports a 3.4% incidence overall but higher incidences in some populations of Chinook and coho salmon (2-73% incidence in small samples sizes), and single individuals infected in pink salmon and steelhead trout.

In Norway, PRV is now known to be the causative pathogen for Heart and Muscle Inflammation (HSMI) disease in Atlantic salmon. Di Cicco et al. (2017) has similarly reported PRV and HSMI on one BC salmon farm during studies of Atlantic salmon production within the SSHI. However, the effect of PRV in Pacific salmon remains an active topic of research/debate and was recently the focus of a workshop (Exploring PRv and HSMI in Europe and BC) hosted by the BCSFA (Nov. 27/28 2017). A summary of this workshop will be distributed shortly. At this time, we know that Pacific salmon are susceptible to PRV (i.e., virus can infect Pacific salmon) but that HSMI-like lesions are not as strongly associated with infection. However, a disease classified as jaundice/anemia has been associated with PRV infections in BC Chinook salmon (Miller et al. 2017). Similar diseases in Rainbow trout and Coho salmon associated with various strains of PRV have been identified in Norway (Olsen et al. 2015; Hauge et al. 2017), Chile (Godoy et al 2016), and Japan (Tomokazu et al. 2016). However, Polinski et al. (2016) reports that sockeye salmon infected with PRV exhibit a remarkable lack of response to the virus at 2 and 3 weeks after infection even though substantial viral amplification occurred during this period.

The synopsis above is one perspective that is not supported by all council members who have different views given the emerging and often conflicting scientific evidence presented. This opposing view observes that there are still many questions about the association of PRV and HSMI in B.C. In Norway, PRV has been present in fish that exhibit HMSI suggesting it may be a causative agent but other factors (environmental and the presence of other pathogens) appear to be necessary to cause disease. This leaves many important questions to be explored and researched. All experimental exposures of the B.C. strain of PRV to Pacific and Atlantic salmon in BC have failed to induce disease or mortality. These failed challenge studies have been used to suggest PRV in BC has a low ability to cause disease (low virulence) for these species (Garver et al. 2016a; Garver et al. 2016b).

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[3] For further discussion on the time period of introduction to BC coastal waters, see Kibenge et al. 2017. PLoS ONE 12(11): e0188690.

[4] Also see Siah et al. 2015.

Experts at DFO are actively involved in this field of research and additional information can be found at the following website:

http://www.dfo-mpo.gc.ca/science/aah-saa/species-especes/aq-health-sante/prv-rp-eng.html

MAACFA stresses the importance of vigilantly monitoring for all pathogens that have the potential to seriously harm farmed and wild salmon. As in the case of human health, where new disease and health discoveries are common, scientists will continue to discover and document previously undescribed freshwater and marine pathogens and diseases because our knowledge of such organisms is incomplete and advancements are occurring in detection processes and techniques.

MAACFA supports the Strategic Salmon Health Initiative that focuses on discovering the pathogens and their potential for diseases that may undermine the productivity and performance of B.C. salmon, their evolutionary history, and the potential role of exchanges between wild and cultured salmon. This work should accompany additional research on the clinical affects, responses, and epidemiology of specific pathogens and diseases on various salmon species. While SSHI is presently focused on identifying all pathogens present in farmed, hatchery, and wild salmonids in B.C., our council also supports studying the potential impact and risks of new pathogens. The latter research requires additional Level 2 confinement facilities in order to undertake this research in a timely and safe manner. MAACFA notes that over the next 2-3 years, we anticipate a significant advancement in research on pathogens, effects, and risks to wild Pacific salmon.

Sea Lice

The council received two presentations on sea lice and drew on a vast amount of scientific material accumulated in the past 20 years, as briefly summarised below.

Sea lice are external parasites common in marine waters around the world and commonly observed on adult Pacific salmonids. However, sea lice should not be present on juvenile Pacific salmon shortly after they enter marine waters. This is because sea lice present on adult returning fish die when the adults move into freshwater. The temporal separation of adult salmon migrations in the summer and fall is sufficient so that the sea lice that are shed will not survive through to the following spring when small juvenile salmon migrate into coastal marine waters. Juvenile salmon are naturally vulnerable to opportunistic infections from sea lice, but the incidence of sea lice normally builds slowly as the juvenile salmon rear and grow in the first several months in seawater (see Jones and Beamish 2011). If immature Chinook salmon, coho salmon or Pacific herring carrying sea lice are present in coastal waters, they can act as reservoirs for sea lice enabling infections of juvenile wild salmon. Likewise, the presence of sea lice on farmed salmon acts as a reservoir for sea lice infections of juvenile wild salmon.

An elevated incidence of sea lice on juvenile salmon around net-pen salmon farms has been commonly documented around the world, including B.C., and continues to be a critical issue in many regions (Revie et al. 2009). Infestation of sea lice on juvenile salmon in B.C. was first reported in the summer 2001 in the Broughton Archipelago (upper Johnston Strait) and documented by the Pacific Fisheries Resource Conservation Council (PFRCC 2002) and Morton and Williams (2003)[5].

An interim sea lice management plan was established in February 2003 for farms within the Broughton Archipelago only, and a comprehensive plan for British Columbia was established in November 2003. The table below was reproduced from page 10 of the *BC Finfish Aquaculture Regulation: Information Review and Progress Report* (1/22/2007) produced by the BC Salmon Forum. There have been condition of license updates, but they largely remain in effect today.

[5] Notably, neither the 'Summary report of the salmon aquaculture review' (1999) conducted for the B.C. government, nor the Auditor General's Report on Aquaculture in B.C. in 2000 mention sea lice as an issue even though the issue was well documented in Europe. http://www.eao.gov.bc.ca/files/ea_review/SAR_summary_report.pdf

Sea Lice Management Plan (November 2003) for salmon louse *Lepeophtheirus salmonis*
• Sea lice monitoring and action are treated separately within the framework of Fish Health Management Plans
• Adherence to program is a requirement of license
• Standardized protocol for monitoring and sampling farm stock for sea lice is established
• Sea lice monitoring required a minimum of once per month and reported to the province
• Statistics for lice counts are submitted to the Fish Health Data Base which are made public on the governments website
• Action must be taken when motile lice levels reach 3 (all stages) at any time of the year and monitoring must increase to twice monthly
• Action during the spring out-migration of juvenile salmon must be include treatment or harvest if lice levels reach 3 motile lice per fish
• Provincial monitoring of active sites ongoing throughout the year, but increases during the 2nd quarter, coinciding with out-migration of juvenile wild stocks.

Understanding the Issue[6]

Parasites are highly evolved animals with specialized life histories with effective transmission mechanisms needed to locate new hosts. A parasite feeds off its host but must do so without killing the host before the parasites completes its life cycle (i.e., its virulence or host mortality is low). However, virulence may increase under environmental conditions that provide high availability of other hosts or when competition for host resources increases and the parasite seeks an alternative host. The challenge of managing sea lice on salmon farms reflects these natural responses and evolutionary pressures determined by individual lice within their localized environment.

Sea lice also have a high reproductive capacity and their abundance can increase rapidly. Once mature, a female may survive for about 200 days and produce about 10 pairs of egg strings during that period; depending on temperature. At 10°C, the time to egg hatching is only eight to nine days (for *Lepeophtheirus salmonis*) and it takes about one month for a louse to mature on a host at this temperature. For more detained consideration of the life cycle of sea lice, see Boxspen (2006).

[6] In B.C., there are two species of sea lice that are the species of interest: Lepeophtheirus salmonis (the salmon louse) and Caligus clemensi (a species with multiple hosts in B.C. waters, particularly Pacific Herring).

The issue of greatest concern is the transmission of farm-produced sea lice to wild Pacific salmon. Without sea lice treatments on farms, a farm can become a source of huge numbers of infective stage sea lice (nauplii) that can affix to juvenile Pacific salmon in proximity to a farm source. While we now know that these nauplii can be shed by the host before the host reaches a much larger size and maturity, there is a risk that wild Pacific salmon are more vulnerable to sea lice than farmed Atlantic salmon. Indeed, beyond a possible problem of skin quality, issues of sea lice infestation on farmed Atlantic salmon seldom appear, in part because farmed salmon are well and regularly fed and live in a protected environment.

The impact of sea lice on wild Pacific salmon is greatest during early marine life when the ratio of the size of a mature sea louse to the juvenile fish is the greatest. There is also clear evidence that the effects are more severe with increasing lice loads (the number of lice on an individual salmon). Effects can be direct mortality with high loads or indirect through a weakened physiological state, poor competitive ability to find food or increased vulnerability to predation. Indirect effects can therefore lead to mortality or reduced growth and lower lifetime fitness. Ultimately, effects on individuals could accumulate into population level effects such that the productivity of a natural population (number of fish returning to natal spawning areas and number of progeny produced) is decreased. Declining numbers of spawning salmon over time then threaten the sustainability of the population and the fisheries that depend on them. We also know through controlled lab studies that the level of natural (or innate) resistance to sea lice among juvenile Pacific salmon is species specific. For example, compared with the other four species of Pacific salmon, pink salmon are considered the most inherently resistant to disease related to infestation from sea lice, despite their tiny size when they migrate to sea. Based on trials, scientists have (Jones et al. 2008; Jones and Hargreaves, 2009) estimated that the lethal infection level for pink salmon averaging less than 0.7g was 7.5 sea lice/g.

The University of Prince Edward Island is leading a project to provide important answers in this area and have developed the world's largest known database of sea lice monitoring. Ongoing meta-analysis of data from several sea lice monitoring programs across the B.C. coast over a 17-year period (2001 – 2017) collected from over 300 locations covering 12 regions along the B.C. coast, and involving approximately one million fish captured shows that, outside of a peak epizootic event in 2004, 90% or more of the thousands of migrating, juvenile pink salmon sampled each year had no sea louse on them in 8 of the years; in the remaining 6 years 75-90% of the fish had no lice. Moreover, for the small percentage of fish having a louse during these 15 years, the average number of lice on a single fish was never greater than 2 lice per fish.

While the scientific literature is rife with papers documenting the type and extent of the effects of deliberately infecting wild salmon with sea lice (often by placing a mature louse directly on the fish), most have used high lice loads to trigger mortality and few have examined the threshold load to trigger harm. While there is no doubt that the risk of mortality varies with the number of lice and the size of the host, the challenge of demonstrating impacts or harm on natural populations of Pacific salmon has yet to be met, primarily for two reasons:

1. Subsequent to infection in their early marine life, individuals continue to grow/survive at sea, but the rate of survival maybe depensatory (mortality rates continue to increase) or survival could be compensatory (reduced juvenile abundance may enhance the subsequent survival of others within the cohort).
2. Enumeration programs in the natural environment are seldom adequate to quantify the production of juvenile salmon and the subsequent adult returns (for a specific brood year). Consequently, demonstrating a causative relation between sea lice infection, juvenile salmon survival and subsequent effects on numbers of adult spawners is seldom done quantitatively, leaving inferences between cause and effect/impact.

However, some researchers believe further direct field study is required similar to those already conducted in Norway and Ireland on native Atlantic salmon (*Salmo salar*). These studies compared the marine survival of untreated juvenile Atlantic salmon released from hatcheries paired with those treated with the chemical therapeutic Emamectin benzoate (SLICE©) to protect them from sea lice infestation as they pass salmon farms (the pair share common environmental effect) as they migrate seaward from coastal fjords. An analysis of all of these studies (118 release groups from 1996 through 2100) reported that the relative survival rate was 18% better for treated versus untreated groups, but this increased to 70% better when control groups had a poor survival (Vollset et al. 2016). When the environment was poorer, the difference between treatments increased significantly; but when the environment was better (higher survival rates in control groups), there was little effect of treatments. These authors thus provided support for the hypothesis that sea lice contribute to the mortality of salmon, but also indicated that the population-level effects of lice on wild salmon depend as much on environmental conditions as on treatment. Extrapolating these results to B.C. suggests only modest population level effects on wild salmon but the outcome can differ significantly between years as noted above in point 1.

Management of sea lice on salmon farms in British Columbia is regulated by DFO to minimize the risk of harm to wild juvenile salmon. Management actions (treatment with therapeutics) can be highly effective and can significantly reduce incidence within farms for a few months. New regulations established in 2003 (outlined below) saw salmon farmers use the therapeutant Emamectin Benzoate (sold under the commercial brand of SLICE©) to manage sea lice on salmon farms. Management has been largely successful at reducing sea lice abundance below threshold levels during juvenile outmigration (2017 BCSFA Sustainability Progress Report; also see Beamish et al. 2011, Peacock et al. 2013). But in 2015, an increase in sea lice abundance was again observed within the Broughton Archipelago (Bateman et al. 2016). The immediate speculation to the cause was changing environmental condition: increased temperatures during the fall and winter periods.

Another expressed concern is possible resistance in sea lice to the treatment with SLICE©. Abundance on lice on farms have returned to levels seen prior to 2015, but farmers always work to develop new management tools to guard against the development of resistance. Resistance in sea lice has been documented in Europe but not to-date in B.C. One recent hypothesis purports that abundant natural populations of Pacific salmon could reduce the probability of resistance developing (Kreitzman et al. 2017), which adds an evolutionary perspective to the ecological interaction of sea lice, salmon in salmon farms, and the importance of sustaining healthy natural populations in B.C. Only in British Columbia do farmed salmon (mostly Atlantic) coexist with abundant wild salmon populations. These authors argue that sustaining these large natural populations provides the ecological service of prolonging efficacy; where large natural salmon populations mixing with sea lice produced in localized salmon farms dilute the genetic change in sea lice towards increasing resistance. Their hypothesis is an interesting perspective that supports this council's stated guiding vision of sustaining abundant wild Pacific salmon populations.

Sea lice management on salmon farms will likely continue to be a significant cost to the industry and for investment in integrated pest management tools including: alternative treatments via therapeutic controls, research into vaccines, mechanical removal, cleaner fish, and using well-boats for fresh-water bath treatments (see 2017 BCSFA Stewardship report).

Sea lice do pose a threat to wild Pacific salmon but one that may be controlled with continued investment and research, area management of farms, and greater emphasis on the restoration of healthy, abundant wild Pacific salmon populations. Some on the council believe the experience around the globe and over many years of salmon farming is not encouraging. For the medium term (5 to 10 years), we expect the managing sea lice from salmon farms to be an on-going risk and significant cost to manage. Consequently, MAACFA is supportive of the comprehensive sea lice monitoring and management strategies and viral outbreak management plan developed by the BCSFA. While these *ad hoc* approaches were designed to address specific issues, they provide some useful lessons for the development of broader strategies and processes in the future beyond baseline data. In particular, they could both form part of a more comprehensive salmon health initiative that would include dealing with specific diseases and pathogens in a prescriptive way but allow for more diverse and comprehensive measures to deal with health issues within specific geographic areas or at a federal or provincial scale.

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Theme 5 — Alternate Technologies and Approaches

Over the 30-plus years in B.C., the salmon aquaculture industry has demonstrated substantial improvements in environmental sustainability (2017 Sustainability Report[7]) as reflected in the much broader list of issues of concern in the past, including genetic impacts of escapees, contaminants and pollution at farm sites, ecological impacts, use of antibiotics, sea lice infections and transfer to wild salmon, and pathogens and disease. Advances in technology and salmon farming practices have addressed and continue to address a number of concerns associated with net-pen salmon farming. The following is a brief description of the current status of several environmental concerns.

<u>Escapes of Salmon from Net Pens</u>

Escapement of non-native Atlantic salmon into B.C. waters has been and continues to be a scientific issue and social concern as demonstrated by the Auditor General's 2000 Report *Salmon Forever: An Assessment of the Provincial Role in Sustaining Wild Salmon* and that it is a

[7] http://bcsalmonfarmers.ca/wp-content/uploads/2015/01/BCSFA_SuspReport_2017_WebSec.pdf

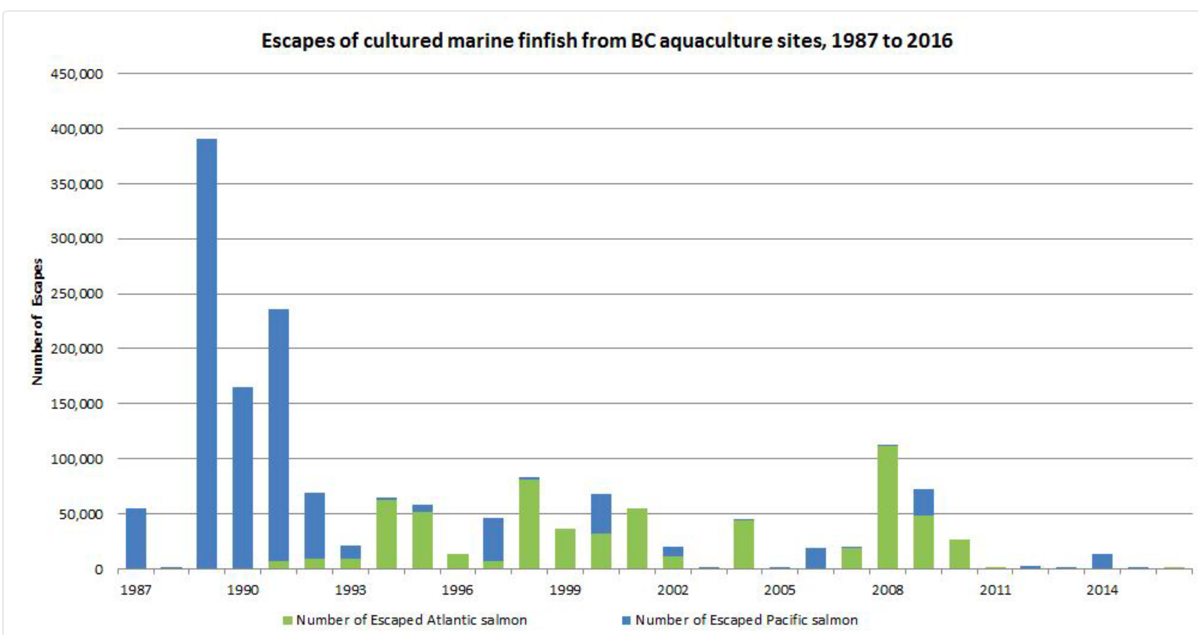
major criterion for ranking in the Seafood Watch program. There are two primary concerns, genetic impact on Pacific salmon and escapees outcompeting wild Pacific salmon.

Unlike the two leading producers of farmed Atlantic salmon (Norway, and UK), where wild Atlantic salmon are endemic to those regions, genetic impacts of escaped famed salmon in B.C. are limited because Atlantic salmon cannot cross breed with Pacific salmon. Atlantic salmon have different chromosome numbers from Pacific salmon.

Improvements to net-pen technology have greatly reduced the number of escapes (both juvenile and larger fish) such that recently documented escapes are trivial (a few to tens of fish). Previous events had involved thousands of fish (Figure 3). Of note, the escape of Pacific salmon in 2014 was an escape of steelhead trout into a landlocked lake. Thus, the risk of Atlantic salmon outcompeting Pacific salmon is likely minimal. This change has come about because net-pen infrastructure (including new net pens) and technologies have been progressively upgraded in an on-going program, with over $200-million being invested in the past three years. See attached release from Marine Harvest:

http://marineharvest.ca/about/news-and-media/2017/poseidon-contract/

Figure 3. Number of escapes of both Pacific and Atlantic farmed in B.C. from 1987 to 2016.



Graph source: http://www.pac.dfo-mpo.gc.ca/aquaculture/reporting-rapports/escapes-evasions/index-eng.html

The risk of Atlantic salmon escapees establishing breeding populations in B.C. also appears to be minimal based on available past evidence. Foremost, deliberate releases of millions of juvenile Atlantic salmon (sourced from around the world, as well as from Eastern Canada) have failed to produce a feral population at multiple locations in B.C. Also, there is no example of a sustained population of Atlantic salmon in B.C. resulting from the farm salmon escapees, as evidenced by DFO-implemented the 'Atlantic Salmon Watch Program' established in 1991 as a direct response to the expressed concerns when escapee numbers were much higher than current levels. This two-decade long program that monitored B.C. river systems has found no evidence of established populations of Atlantic salmon in the wild. One independent publication reported the rearing of juvenile Atlantics in the Tsitika River (NE Vancouver Island, Volpe et al. 2000), but the Atlantic Salmon Watch Program found no evidence of a continued population over time. DFO initiated further stream surveys in southern B.C. following the recent major escape of Atlantic salmon from a farm in Washington State.

Contaminants and Pollution

Chemicals containing copper, zinc, and cadmium have historically been used on nets to reduce fouling, just as they are used on the bottom of marine-going vessels. The pollution issue relates to these contaminants settling on the ocean floor as debris or effluent related to net cleaning. Copper-treated nets will soon to be eliminated in B.C. and the use of copper-treated nets already has been greatly reduced, thereby substantially reducing the loading of copper to the benthos. Both the Canadian Organic Aquaculture Standard and the Aquaculture Stewardship Council (ASC) certification are explicit in not allowing the use of copper as an antifoulant. However, the lack of data to confirm this matter is a concern and has been flagged by some members.

Ecological Effects

Possible ecological effects are more diverse and some continue to be considered risks to the natural environment; for example, predator mortalities in nets, small forage fish in nets, lights on farms, nutrient addition to surrounding waters, bottom impacts, and use of fish meal and oils in diets. Most of these effects are now seen as very minor and localized risk, but some concerns continue.

Fish Meal and Oil Supplies

The use fish meal and oil in agri-feeds (for agriculture and aquaculture) is a continuing concern globally but the situation has improved over the past decade. In terms of global fishery catches (all species), the share of world fish production utilized for direct human consumption has increased significantly in recent decades, up from 67% in the 1960s to 87%, or more than 146 million tonnes, in 2014 (UNFAO 2016[8]). Almost all of the remaining 21 million tonnes was used for non-food products, of which 76% was reduced to fishmeal and fish oil in 2014; the rest

[8] FAO. 2016. T*he State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all.* Rome. 200 pp.

being largely utilized as fish for ornamental purposes, culture (fingerlings, fry, etc.), bait, pharmaceutical uses, and as raw material for direct feeding in aquaculture, for livestock and for fur animals. In B.C., the formulation of diets for salmon aquaculture has been a focus of research to substitute sources of plant protein and oils to replace fish meal and oil. The BCSFA 2017 *Sustainability Progress Report* provides examples of this research (page 20). As a potential risk to B.C. wild Pacific salmon, this issue is not considered a risk to wild Pacific salmon.

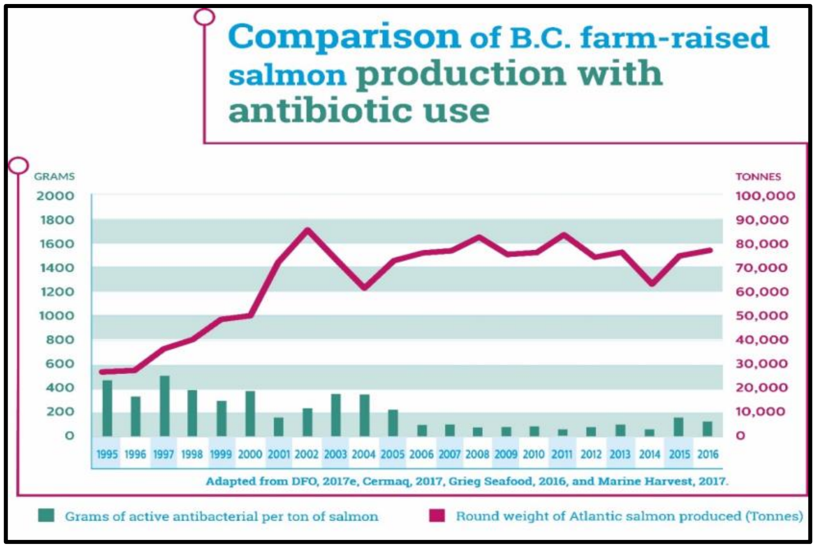
Use of Antibiotics

Antibiotics are a key tool with any issue of health management with humans or farmed animals. Thus, the use of antibiotics continues in salmon farming but reduced use of antibiotics in net-pens operations is important area of progress. Antibiotic use is prohibited under the certified organic standard and some of B.C.'s farmed salmon producers have this standard. The BCSFA Sustainability Report (page 18) documents the declining antibiotic use over time (Figure 4). It also presents the other measure of antibiotic use (page 19), which is the number of treatments per production cycle. Between 2014 and 2016, the number of treatments per production cycle was between 1.4 and 1.6 times (page 19).

The reduction in antibiotic use is associated with improved fish rearing conditions and specifically with the increased use of vaccines. Before smolts enter marine waters, they are inoculated against five common bacteria pathogens potentially causing Furunculosis, Vibriosis, Moritella viscosa, Bacterial Kidney disease, and Enteric Red Mouth disease and the virus that causes Infectious Hematopoietic Necrosis (IHN). IHN is an endemic virus to Pacific salmon but is highly infectious to Atlantic salmon and caused a major outbreak in the early 2000s (St. Hilaire et al. 2002, Saksida 2006). However, research with RNA-based vaccines[9] resulted in a highly effective vaccine (Garver et al. 2013, Long et al. 2017) now used by the salmon farmers to control this diseases impact; achieving essentially complete resistance in Atlantic salmon to this virus. Vaccines are presently being developed to protect against the two bacterial pathogens, which will further reduce the use of antibiotics in the salmon farms.

[9] http://sitn.hms.harvard.edu/flash/2015/rna-vaccines-a-novel-technology-to-prevent-and-treat-disease/

Figure 4. Comparison of B.C. Farm Raised Salmon Production with Antibiotic Use



Data in Figure 4 were not verified by the MAACFA but all antibiotic use in B.C. must be prescribed by a licensed veterinarian and could be verified if required. Antibiotic use is prohibited under the certified organic standard.

Antibiotic use today specifically targets Yellow Mouth disease (Tenacibaculosis), seen during early sea entry of Atlantic salmon smolts, and Salmonid Rickettsial Septicaemia disease (Piscirickettsiosis), a disease that seems to increase with warmer waters. With the reduction in application of antibiotics and development of vaccines, and assuming that the efficacy of these vaccines continues, the use of antibiotics is not seen as a significant risk to wild Pacific salmon. Chilean researchers are investigating a vaccine against sea lice.

Salmon Farming Technologies

Innovations and development in technology have been documented through the history of salmon aquaculture. Today, technological advancements are seen as a way to mitigate environmental impacts and reduce potential risks to wild salmon. A brief description of developments in salmon farming technology follows.

A. Ocean-based Technologies

Advanced net-pen systems — Ocean-based salmon farms have evolved significantly over the last 30 years, with systems becoming larger and more robust, and relying on mooring and anchoring that is able to withstand extremely harsh environments. The results have been better conditions to promote fish health and growth, drastically reduced incidents of escapes, and improved working conditions for staff.

Farms today are constructed of rigid steel that provide an ideal platform for farming, or flexible plastic that is better suited for dynamic loading by the sea. Thus, steel systems are suitable for sites with moderate exposure and strong tidal currents, while plastic systems are designed for high waves and rough water. When used in B.C., both systems are equipped with a double-net system designed for optimal containment of farm stock, while providing a barrier to any predator that may be near.

Mooring plans for farms are developed after significant data collection that enables wave and current analysis and a fully modeled system and detailed design. Farms are moored to withstand the highest recorded waves at a site and the highest possible currents. Inspections of structures are conducted on a regular basis using remotely operated underwater vehicles (ROV) and divers. And, farms in B.C. are equipped to address sudden harmful plankton blooms and that has resulted in significantly fewer mortality events. As well they are equipped with oxygenation systems that ensure the farming environment remains optimal for salmon health.

Nets in use today are stronger and typically made from polyurethane rather than nylon. New nets are more ridged, UV protected, and able to withstand much more abrasion. Nets on farms today are washed on a regular basis with remote operated net-cleaning systems to ensure optimal flow of water through the system. New nets and washing systems have almost eliminated copper-based paints, which have historically been used throughout the marine industries to reduce fouling.

A technological development in Norway that is part of an integrated salmon aquaculture process is near-shore floating containment systems. These floating systems are semi-closed and draw seawater from depth to provide temperature and oxygen control. The water is pumped creating a current for salmon to swim against which keeps them on the move and feeding. It is early days for these systems, but the expectation is that they can grow fish from 100 g to 1 kg more efficiently than in land-based systems while reducing risk from sea lice and exposure to harmful algae. Currently in B.C. the average body size of Atlantic salmon at sea entry is approximately 120 grams.

In B.C. Agrimarine Technologies Inc. has developed a floating containment system that is currently being used to raise steelhead salmon in Lois Lake near Powell River. The Agrimarine System has allowed for controlling water temperature, providing an optimal level of oxygen, and improving fish health. The system is also designed to remove solid waste through a nutrient recovery system.

Larger salmon farming companies in Norway have also begun experimenting with growing their juvenile salmon to a larger size before moving them to ocean net-pens, thereby limiting the duration of the salmon life cyle in seawater. Therefore, Norway has made a significant investment in building these “post-smolt” facilities that are typically large-scale, land-based recirculating aquaculture systems (RAS). This may be a notable development for B.C. to monitor. If applied in B.C., these delayed releases may provide flexibility when a marine production cycle is begun and could reduce the numbers of months of marine culture required in one production cycle.

Off-shore farming systems —The other notable technology is the world's first offshore fish farm deployed in Norway in August 2017. Designed and operated by Salmar, Ocean Farm 1 is 110 metres wide, 68 metres high, can contain 250 cubic metres in volume and withstand magnitude 12 earthquakes. The farm is designed to raise up to 1.5 million fish (10,000 metric tonnes harvest) in 14 months and is undergoing its first trial now. The infrastructure and cost was over $110-million CDN. (https://www.salmar.no/en/offshore-fish-farming-a-new-era).

B. Land-based Recirculating Aquaculture Systems (RAS)

Salmon farmers around the world have been using and evolving land-based systems for more than 40 years, but currently, the vast majority of land-based systems are used for smolt production (juvenile salmon that are ready for introduction to seawater) and brood-stock programs. In Norway, there are approximately 190 land-based fish farms operating, most are primarily salmon smolt farms with smaller facilities producing various other species. The largest land-based operation has a capacity to produce more than 3,000 metric tonnes of smolt per year. In B.C., there are currently approximately 25 freshwater facilities raising salmon and other fish (not including the federal government's hatchery programs), the vast majority used for raising smolts, which are too small for the food market. A few land-based facilities rear salmon to market size[10].

In the past 10 years, there has seen a significant increase in interest about farming salmon on land for their entire lifecycle and to market size. While a variety of small projects exist around the world, none operate at a production level more than 1,000 metric tonnes. Their financial viability is also a concern.

While significant progress has been made in technical aspects of land-based closed containment aquaculture, there are a few challenges that will likely have to be overcome including rearing fish at higher densities (kg/m^3) than net-pens, controlling early maturity of fish, particularly males, eliminating off-flavouring, and filtration and removal of wastes.

There are two distinct viewpoints expressed by the committee, with some members believing that there is evidence that land-based closed containment aquaculture is on the verge of worldwide growth, and that British Columbia should transition all of its production to this method. Other members believe that there is no business case for policies to mandate this transition and there are significant biological, technical, and financial obstacles to overcome. These members suggest that land-based production is years away from being more than a small

[10] Includes: Golden Eagle Aquaculture, Agassiz, B.C. (coho salmon), Taste of B.C. Aquafarms, Nanaimo B.C. (steelhead trout), and West Coast Fishculture (Lois Lake) Ltd., Powell River, B.C., Kuterra Salmon, Alert Bay, B.C.

fraction of the global output, and when it happens those facilities will most likely be near major markets for salmon consumption, not in rural coastal communities.

Committee members urging for a transition away from net-pen rearing, believe that land-based, closed containment aquaculture now represents an opportunity for B.C. to play a leading role in an emerging market. B.C. has important advantages that position the province to grow its aquaculture industry with premium-priced, sustainable seafood that is in demand in key markets, while attracting significant new investment. Known developments (proposed and operating) for RAS around the world are listed in Figure 5 below.

This perspective contends that the province already holds a leading role in the development of RAS, having pioneered the use of the technology for the grow-out of finfish to full market size. A skilled labour pool and support infrastructure, including feed suppliers, processing and distribution are already in place to serve the net-pen or land-based industry.

Figure 5. Planned and Operating RAS Atlantic Salmon Production: status as at 2017 as per Conservation Fund's Freshwater Institute.

Company	**Country**	**Planned Production**	**Status**			**Comment**
			Planning	Construction	Operating	
Atlantic Sapphire/ Miami	USA (Flor.)	90,000	x	x		First 8000mt unit under construction
Nekst	Norway	20,000	x			Post smolt and market salmon production
Akvafarm Rjukan AS	Norway	10,000	x			Final financing coming together
Whole Oceans/Emergent Holdings	USA (ME)	5,000	x			
FishFrom	Scotland	3,600	x			Financing complete, construction spring 2017
Nordic Aquafarms	Norway	2,400		x		1 ton pilot in operation
Atlantic Sapphire/ Langsand Laks	Denmark	2,000		x	x	500mt current. Expansion to 2000mt underway
Danish Salmon	Denmark	2,000			x	
Inland Seas/Dyne Aquaculture	USA (IA)	2,000	x			Financing in place, break ground in early 2017
Niri AS	Scotland	2,000	x			
Atlantic Salmon South Africa	South Africa	1,500	x			
Jurassic Salmon	Poland	1,000			x	
Yantai Salmon Farm	China	1,000			x	
Xinjiang E'he Construction and Investment Company	China	1,000			x	Recently switched from trout to AS
SmögenLax Aquaculture AB	Sweden	1,000	x			
Swiss Alpine	Switzerland	600		x	x	
Palom	USA (ME)	600	x			Still trying to finalize financing
Sustainable Blue	Canada (NS)	500	x		x	Expansion planning to 500 MT
Kuterra	Canada (BC)	300			x	
CanAqua Seafoods	Canada (NS)	100	x		x	Also produce halibut
BDV	France	100			x	
Total Production (mt/year)		**146,700**	**135,985**	**95,000**	**8,355**	

B.C. has abundant land with access to freshwater and saltwater, as well as low-cost hydropower located close to markets and transportation infrastructure. Analysis provided by some committee members suggests the combination of land values and existing infrastructure make locations where most aquaculture employment is currently centered ideal for land-based aquaculture. As a result a transition could be managed in such a manner that it need not lead to a loss of employment or other local economic benefits.

The opportunity to be a leader in an emerging industry is currently considered by some to be time-sensitive. Development of the industry in Europe is proceeding, supported by increased product demand, growth constraints of ocean net pens that have experienced rising costs of production due to biological constraints, and investment in research into closed containment and incentives for investment in innovation. Norway has instituted strict new performance-based regulations to guide the growth of net-pen farms, whereby increases will be restricted to 3% each year, while poor performance could result in a contraction of the same amount (assessed per farming area). The Norwegian government, industry and research institutions are cooperating on the 50%-government-funded CtrlAQUA research consortium whose goal is to develop technological and biological innovations that will make closed aquaculture systems a reliable and economically viable technology. Norway has a goal to increase closed-containment aquaculture production volume five-fold, and its value eight-fold by 2050. http://ctrlaqua.no

This perspective believes the business case is being made and cite a February 2017 research report, entitled "Deep dive into land-based farming", and prepared by DNB Markets — a division of Norway's largest bank to make this case. DNB reported that, "production costs for traditional and land-based farming are starting to converge as biological costs for sea-based farming increase and technological advances reduce land-based costs…."

Acknowledging that data remains scarce, the report goes on to say: "We believe certain land-based projects show good enough prospects to be considered viable investments and believe meaningful volumes from land-based farming will materialize post 2020. Land-based success or failure will depend on traditional farming's ability to resume growth."

The full report is available at: http://www.kuterra.com/files/1314/9669/9783/DNB_-_Deep_dive_into_land-based_farming.pdf.

To accelerate the transition to fully land-based aquaculture in B.C., proponents are proposing an "aquaculture park". The concept is designed to lower the initial capital cost and time to market for new land-based farms through advanced permitting and development of shared basic infrastructure, such as water supply, power and effluent treatment, which can be shared by "tenant" RAS producers. The concept proposes to kick-start development in increments of 3,000 to 5,000 metric tonnes per year facilities. By 2027, land-based closed containment could replace current production volumes from open net pens (approximately 70,000 metric tonnes), attracting $1.7 billion in capital investment and generating $600 million in sales.

The aquaculture park concept lowers cost and time to first cash flow, making it more attractive to investors and operators alike. Permitting and regulatory issues need to be addressed to ensure these conceptual savings are realized. To attract early capital, incentives in the form of tax grants, accelerated depreciation, preferential rates, etc., are needed to accelerate the development of the industry to at least equal — and potentially exceed — current net-pen salmon production within a decade. Such assistance could decline over time as facilities demonstrate technical and operational efficiency and begin to attract credit-based debt capital.

The United States is B.C.'s most important market for farmed salmon. It's expected that the U.S. is likely to follow suit if B.C. is unable to act upon its "first mover" advantages discussed in the opening paragraphs. With few U.S. states allowing net-pen salmon farming, the U.S. is the leading global importer of fish and fishery products, with 91% of the seafood consumed originating abroad, half of which comes from aquaculture. Driven by imports, the U.S. seafood trade deficit grew to over $14 billion in 2016. Not surprisingly, financing (in part through DNB) and permitting of the largest land base RAS project for farmed Atlantic salmon is underway by Atlantic Sapphire in Miami, Florida. Atlantic Sapphire is building on the knowledge gained through the operation of its 500 metric tonnes (expansion to 2,000 metric tonnes underway) Langsand Laks farm in Denmark.

The material that follows comes verbatim from a document entitled "How to launch a land-based closed containment (LBCC) Atlantic salmon aquaculture industry in B.C." prepared by Gary Robinson of GRV Inc. It also includes a regulatory regime suited to land based technologies that capture and control waste and remove interactions with wild fish.

> "Three things are needed to create and accelerate the growth of a significant B.C land.based fish farming industry:
>
> 1. Regulatory changes;
>
> 2. Financial incentives; and
>
> 3. The creation of an aquaculture park site in B.C. that is large enough to host up to 50,000 metric tonnes of LBCC Atlantic salmon production.
>
> Failure to enhance Canada's competitiveness by executing these elements will likely result in the bulk of LBCC facilities being built in the continental United States.
>
> <u>Regulatory Changes</u>
>
> The years that it takes to get permits for land-based facilities are a major hindrance to new market entrants. By creating a streamlined, timely permitting process, B.C. and Canada can create a competitive advantage that will help attract new LBCC investments to B.C. The regulatory changes needed are as follows:
>
> 1. Streamline the process for obtaining all of the permits for LBCC fish farm facilities (e.g. effluent discharge, groundwater extraction, aquaculture licensing, etc.) so that it is timely. In Norway it took developers of a 20,000 metric tonne facility four months to receive their discharge permits. Providing the discharge permits (e.g. for nitrogen, phosphorus, etc.) before detailed design work commences is critically important to attracting new investments.
>
> 2. Create a process for obtaining blanket discharge permits for aquaculture parks. Ideally the whole 50,000 metric tonnes would be permitted when permits are granted so that additional production units can be quickly added.

3. Create a pathway and supporting regulatory framework for the safe importation of Atlantic salmon eggs from outside B.C. Access to the strains of eggs that perform best in recirculating aquaculture systems (RAS) is essential to be able to optimize fish performance, profitability, and to develop a B.C.-based broodstock program.

Financial Incentives

Financial incentives are needed for two reasons:

1. To reduce early stage investor risk. Although our models show that reasonable (>14%) returns are probable, LBCC investments are still high risk because no company has built a scaled-up facility and proven profitability at scale. Incentives are, therefore, needed to encourage the construction of the first commercial scale (e.g. more than 2000 metric tonnes per year) B.C. LBCC facilities.

2. To attract LBCC investments that would otherwise flow to the U.S. Building in the U.S. eliminates currency risk, trade risk, and reduces transportation costs and one's carbon footprint, however B.C.'s existing aquaculture industry ecosystem (e.g. feed suppliers, processors, fish health scientists, distributors, etc.) provides some cost reduction benefits. The B.C. advantage will be lost if we wait and let the industry develop in the U.S. Financial incentives will add to B.C.'s advantages by decreasing financial risk and increasing the risk-return profile for projects built in Canada.

Aquaculture Park

An aquaculture park is a multi-user aquaculture site (100-150 acres) where land, key resources and services are provided and charged to tenants according to their respective use and needs. Aquaculture parks (APs) are attractive because they reduce CAPEX, OPEX, time to first cashflow and risk. Of course APs could be built in the U.S. Canada will only gain a competitive advantage if the permitting process for one or more APs is completed before the concept is mimicked in the U.S., or before stand-alone LBCC projects start the permitting process in the U.S. Once the B.C. AP is fully permitted, then new LBCC proponents could start building their facilities in B.C. immediately, rather than waiting for several years to get permits to build in the U.S. Therefore, ideally the B.C. aquaculture park would be fully permitted and have the first phase of shared infrastructure (influent water supply and waste treatment) built as soon as possible. This will create a competitive advantage for several years, and the financial incentives will maintain that advantage further into the future. Three tranches of funding will be needed to launch the first AP.

1. The first tranche of roughly $2 million will be needed to secure an option on a site, complete the site assessment and permitting process, conduct the preliminary engineering, and complete all of the legal agreements with a utility

provider and the tenants. A team is working to finalize this initial development budget.

2. The second tranche of roughly $11 million will be needed to purchase the land.

3. The third tranche of roughly $32 million will be needed to build the first phase of shared infrastructure that will support 10,000 metric tonnes of annual RAS salmon production. Securing the $32 million will likely be the largest hurdle to overcome in order to build the AP quickly enough in order for B.C. to solidify the first mover advantage in attracting future LBCC investments.

As part of the initial development phase workplan, the team will work with a utility company to clarify the design and class D costs for the first phase of shared infrastructure. All options to raise these funds will then be explored.

<u>What is being done to move this vision forward</u>?

Five individuals with a wide range of business and technical experience in RAS salmon production are assembling a business plan for the development of B.C.'s first AP. Three of the principals worked on the 'Namgis land-based Atlantic salmon RAS project (Kuterra) on Northern Vancouver Island from its inception. This team is collaborating with First Nations, prominent B.C. business leaders, NGOs and government to launch the LBCC salmon farming industry in B.C. at scale."

A larger brief titled "Closed Containment Aquaculture for B.C.", fully explores the economic potential of the industry; its regulatory requirements and jurisdiction issues; and the potential vehicles for accelerating its development.

The brief also acknowledges and explores avenues for meeting constitutional obligations to B.C.'s First Nations, including involving them in planning for the industry at the earliest stages, decision-making, monitoring and enforcement. Thus the transition to land-based closed containment creates an excellent opportunity to meet the government's commitments to reconciliation with First Nations and the United Nations Declaration on the Rights of Indigenous People.

Others on the committee hold the perspective that there are many biological, technological, and financial objectives that will curtail the global development of land-based closed containment aquaculture. This perspective holds that this is in the more distant future and they cite the February 2017 DNB *Seafood Special Report,* noting that while the top line messages in the report look very positive, there are underlying messages that are concerning.

The report states, on its first page, a challenge that has plagued the development of all projects looking to raise salmon to market-size on land: *"Spreadsheet models are only as good as their input variables, for which there are still few, hence this is our best guess based on available input".* In fact, one of the key variables — the market price of salmon — has changed significantly since DNB authored the report. DNB estimated a 2017 price of salmon at NOK/KG$63, while the current price in October 2017 is actually NOK/KG$52.

The authors of the DNB report say that land-based farming success hinges on pace of supply recovery from traditional farming: "*We expect land-based full-cycle production on land to either a) blossom to contribute a substantial share of total production volumes as traditional growth fails to recover, or b) wither, with a few projects causing only a marginal volume contribution as traditional growth manages to recover, reducing the attractiveness of the new technology."* The report goes on to say, *"past land-based projects have not managed to create more than a tiny niche in the market rather than revolutionizing it."*

"Scale and location important for land-based salmon production to blossom

We believe the facilities' scale and location in markets where transportation costs are high, will be critical for the industry to take off.

We expect that the concepts will be rolled out in other regions, in end markets, on a larger scale if proved successful. An example of a player already implementing this strategy is Atlantic Sapphire. Atlantic Sapphire owns Langsand Laks in Denmark, which is currently producing approximately 700 tons and plans expansion to 2,000 tons, while in Florida Atlantic Sapphire is building a facility with planned capacity of 10x the Danish one."

Coincidentally, in June 2017 Intrafish reported that Atlantic Sapphire's Danish land-based salmon farming operations – Langsand Laks – reported a loss in the fiscal year of 2016. Its annual report shows a US$2.2-million loss in 2016 compared to a loss of US$1.2 million in 2015. In 2015, Intrafish reported that Langsand Laks has *"been turning in red figures since its inception"*. In July of 2017, Intrafish reported that Langsand Laks was struck with *"sudden and unexpected mortality, wiping out all the fish in its grow-out system within a period of 15 to 20 hours.*

The DNB report acknowledges the biological challenges faced by raising large fish in a land-based system. *"It is critical to have control over the water quality in the system (to avoid diseases and ensure growth) and over discharge from the facility. Advanced facilities have had problems that have required them to shut facilities down temporarily; for example, a Danish facility had bacteria entering the facility with intake water. Another Danish facility has struggled with emissions, creating odours and having other environmental impacts, causing discontent in the municipality (sources: Undercurrent News and "FødevareWatch).*

In September 2017, seven months after the release of the DNB report, Intrafish reported that Norwegian lenders are cautious on land-based salmon farming, that the risks involved are still too great when it comes to financing most projects. Anne Hvistendahl, head of foods and seafood at DNB told Intrafish: *"It is important to prove to the bank that one has been successful in achieving a fish production cycle before ordinary financing can be counted on if the plan is to have 'stand-alone' financing on such a facility"*. Norwegian bank Nordea is positive about the future of producing larger smolts and land-based smolt production *"however, at this juncture we believe it is appropriate to exploit the marine environment during segments of the farmed Atlantic salmon's life cycle".*

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http://www.kuterra.com/files/1314/9669/9783/DNB_-_Deep_dive_into_land-based_farming.pdf, as of October 27, 2017.

Theme 6 — Transparency and Information Gaps

MAACFA identified a number of factors that have contributed to the public controversy regarding salmon farming. Transparency of information lies at the foundation and it is for this reason that the council recommends greater and easier access to raw and aggregated data for both marine-based and land-based aquaculture operations. In addition, the same sort of transparency should be provided by DFO for the status of B.C.'s wild salmon populations so that the public can have a clear image of their trends and sustainability. A brief summary of factors that have contributed to the public controversy regarding salmon farming follows.

Lack of Transparency — Transparency and accessibility of fish health data from salmon farms remains a specific concern and is a source of mistrust and misunderstandings regarding aquaculture in B.C. While government agencies and employees have the authority to collect farm samples and data required to regulate the industry, routinely they do not make this information available publically in raw or aggregated form. Non-government researchers have experienced difficulty in accessing fish farm samples and data for a variety of reasons. While steps have been taken recently to improve access to data, MAACFA noted that in some instances information made available is not easily accessible or provided in a timely manner.

Uncertainty and Knowledge Gaps — Given the complex nature of pathogens and disease and insufficient research examining the problem, there is a high level of uncertainty and knowledge gaps related to the likelihood of transmission from farmed salmon to wild salmon and the potential effects associated with such transfers. Of particular concern is the possibility of a catastrophic decline in wild salmon populations if a highly virulent pathogen was to be transferred (e.g., an exotic pathogen or mutation of a virus).

State of Science — Scientists with expertise related to disease, salmon farming and wild salmon have divergent views on the potential risk of pathogens spreading disease from farmed to wild salmon. Company veterinarians and some government scientists contend that the risk is low as a result of salmon farming policies and practices. All of the veterinarians that MAACFA heard from believe that the risk associated with salmon farming is low. Other scientists note that given that pathogens and disease do exist on salmon farms, there is a risk for a significant threat to wild salmon and that this risk is too great. The incidence of a pathogen within a net pen salmon farm may be low but the effect of transfer to wild salmon could be much greater in the natural environment. The persistence of these debates/opinions continues to confuse the public's perception of salmon farming. However, healthy scientific debate is a critical element of the scientific method and must not be interfered with. Alternatively, independent advice from qualified committees could be utilized to provide objective assessments of current knowledge, including the development of independent laboratories to conduct monitoring and assessment of fish health on farms (live fish and mortalities included in the audit samples) and local wild salmon populations. Open public reporting of advice and on-going monitoring results would be essential to establish trust in these new processes.

These factors help explain why individuals have such a wide range of views regarding net-pen salmon farming. Firmly entrenched positions have emerged due, in part, to the high degree of uncertainty, conflicting science and lack of transparency regarding the health of cultured salmon in farming operations, and the risk associated with the possible transfer of pathogens (with assumed expression of disease) to wild Pacific salmon.

The council is aware of tools that help improve transparency and accessibility of relevant information. For example, the Pacific Salmon Foundation has developed a data-base tool (Pacific Salmon Explorer) that presents biological data for all 55 distinct salmon populations found in the Skeena River watershed, as well as maps of current human and environmental pressures on freshwater and estuarine salmon habitats. This information provides a snapshot of the status of Skeena salmon Conservation Units and an overview of cumulative pressures on their habitats. The Pacific Salmon Explorer was initially developed for the Skeena watershed, but the tool in now being extended to all watersheds throughout B.C.

Norway's interactive and GIS-based website BarentsWatch site (https://www.barentswatch.no/en/) provides ongoing information and updates related to salmon farming. The council is recommending a similar site be developed in B.C. Examples of the information that could be available on the new website, with the understanding that these should be developed with the interested parties (recommendation 6.1) include:

- Information submitted by industry to the B.C. and federal government in support of applications for new sites, proposed site modifications, or request for a production increase at existing sites (quarterly).
- Monthly fish health data from individual farms, including the number of mortalities and causes of mortality.
- Any diagnosis or treatment of a fish pathogen or pest present in an aquaculture facility, including information on the extent to which the pathogen or pest affects the fish in the facility (quarterly).
- When a farm is infected with a pathogen, information about that infection, its causal mechanism and public notification that a farm is under quarantine or being treated.
- Individual farm records of any substance used to treat fish for pathogens or pests, including the quantity used and the date and method of its administration (quarterly).
- Monthly reports on the results of sea lice monitoring as set out in section 7 of the conditions of licence, increasing to a minimum of bi-weekly during the juvenile wild Pacific salmon outmigration period (March to June). This would include any mitigation or management responses. Annual sea lice abundance and mitigation trends should be reported as well.
- Monthly marine mammal mortality (number and species).
- Individual farm records related to the construction, operation and maintenance of sewage treatment and disposal works including amounts of sewage disposed of (quarterly).
- Monthly light use reports summarizing: type of lights used; the intensity of lights used; the number of lights used; and, dates and times when the lights are used (period of day; season).
- Complete benthic monitoring reports that are required pursuant to requirements set out in the Benthic Monitoring Program, including DVD video data (quarterly).
- Escape reports as events occur.
- Monthly incidental catch reports.
- Following a fish health event, records of carcass disposal (methods, numbers, treatments).
- Environmental events and mitigations taken (ie. Toxic algal blooms) reported quarterly
- Ocean temperatures, salinity and dissolved oxygen at each marine site (weekly averages posted monthly).

Appendix 8 — Previous Reports on Aquaculture

Content reviewed and endorsed by council

Appendix 8 – Previous Reports on Aquaculture

Since 1986, there have been at least 17 reports that addressed aspects of salmon farming in B.C., as well as multiple inclusive marine planning processes. Major planning processes included the Marine Plan Partnership (MaPP) for the Pacific North Coast area of B.C., in which First Nations, the Province of B.C. and stakeholder groups developed comprehensive marine plans with zoning identified to address marine use site applications and development, including aquaculture.

The scope of previous reports varies considerably. For example, the 1986 Report by the Province, *An Inquiry Into Finfish Aquaculture in British Columbia*, had a broad mandate that included tenure approval and monitoring procedures as well as impact on commercial fishery operations, markets, and localized production-related facilities. Between 1997 and 2007, many of the reports on aquaculture were written by provincial and federal agencies to address specific aspects of their regulatory responsibilities, including reports by the BC Environmental Assessment Office, the BC Auditor General, BC Special Legislative Committee, the Auditor General of Canada, the federal Standing Committee of Fisheries and Oceans and federal Commissioner of the Environment and Sustainable Development.

Several presentations made to MAACFA referenced recent reports that addressed aquaculture in B.C., including BC Pacific Salmon Forum (2009), the Cohen Commission (2012) and the Senate Standing Committee on Fisheries and Oceans (2015). MAACFA noted the following points from those reports.

Pacific Salmon Forum (2009)

> *"Everyone calls for facts and science-based processes, but every contending group offers its own 'facts' and the science itself is often contradictory and not always agenda-free."* (page 6)
>
> *"The recommendations made by the Forum in this report are all designed to improve public confidence that wild salmon will survive and thrive in British Columbia; that we'll be able to buy wild salmon in our supermarkets and restaurants or go fishing for salmon with our families and friends while communities throughout the province benefit from the associated economic activity involved. Our recommendations also see a future where salmon farming is viewed as an important economic driver and a legitimate user of the marine environment that is compatible with healthy wild salmon populations."* (page 6)

Cohen Commission (2012)

> "*Of all the expert witnesses I heard from on the topics of salmon farms or diseases, no one told me there is no likelihood of harm occurring to Fraser River sockeye from diseases and pathogens on fish farms.* (volume 3, page 20*)*

"*However, I cannot quantify the likelihood of harm occurring based on the evidence before me. Scientists do not know enough about farmed-wild fish interactions, and about how pathogens present on salmon farms affect Fraser River sockeye, to be able to quantify those risks to wild sockeye.* (volume 3, page 21)

"*… I have concluded that net-pen salmon farming in the Discovery Islands poses a risk of serious harm to Fraser River sockeye through the transfer of diseases and pathogens. The full extent and likelihood of that harm cannot be determined because of scientific unknowns. Precautionary measures should focus on filling the knowledge gaps and enabling DFO to adapt mitigation measures to new scientific information.* (volume 3, page 25)

"I am also satisfied that marine conditions in both the Strait of Georgia and Queen Charlotte Sound in 2007 were likely to be the primary factors responsible for the poor returns in 2009. Abnormally high freshwater discharge, warmer-than- usual sea surface temperatures, strong winds, and lower-than-normal salinity may have resulted in abnormally low phytoplankton and nitrate concentrations that could have led to poor zooplankton (food for sockeye) production." (volume 3, page 59)

Senate Standing Committee on Fisheries and Oceans (2015)

"Our country has the world's longest marine coastline, the largest number of freshwater lakes, a diversified aquaculture industry, a rigorous regulatory regime and world-class aquaculture-related research. Canada is, therefore, well positioned to help supply the growing global demand for fish and seafood and to do so sustainably – environmentally, economically and socially. The Committee supports the goal of doubling Canadian aquaculture production within the next decade." (volume 3, page 1)

"During the past five years, work has also been carried out under the Canadian Council of Fisheries and Aquaculture Ministers (CCFAM) as part of the National Aquaculture Strategic Action Plan Initiative (NASAPI) to address challenges associated with aquaculture governance across the country. The initiative was an ambitious plan and, although a number of tasks have been completed, much remains to be done." (volume 3, page 2)

"During Committee hearings, witnesses often pointed to the need to synthesize the results of current research. They explained that, while a considerable amount of R-D has been conducted on the effects of aquaculture on the environment in Canada and abroad, this body of research has never been compiled, synthesized, and interpreted." (volume 3, page 6)

While not all of the specific recommendations contained in the reports on aquaculture written over the past 30 years have been implemented, the reports have clearly helped guide the evolution of salmon farming in B.C. In addition, those reports have contributed to MAACFA's understanding of aquaculture in British Columbia.

In contrast to most of the previous reports on salmon farming in B.C., this MAACFA report was developed directly by a group representing a broad cross section of British Columbians tasked by the Minister of Agriculture with a wide-ranging mandate, which includes considering whether or not the Province should pursue development of marine-based salmon aquaculture in B.C. Moreover, MAACFA was comprised of members with wide knowledge and divergent views on specific aspects of aquaculture.

The diversity of views has led to robust discussions on key matters, improved the council's understanding of issues and, in turn, informed its advice. The range in perspectives has also had the effect of focussing the council on unifying goals and ensuring that any advice we may offer on aquaculture is seen within this broader aim. Finally, the council was cognizant of the many previous studies and work that has been done on aquaculture in B.C. Our intention is that the council's deliberations add real value to the issue and that its recommendations be pragmatic and implementable, ultimately helping move matters forward.

List of Previous Reports

An Inquiry Into Finfish Aquaculture in British Columbia (1986)

BC Environmental Assessment Office's *Salmon Aquaculture Review* (1997)

Auditor General of Canada's *The Effects of Salmon Farming in B.C. on the Management of Wild Salmon Stocks* (2000)

Office of the Commissioner for Aquaculture Development's *Legislative and Regulatory Review of Aquaculture in Canada* (2001)

Pacific Fisheries Resource Conservation Council's Advisory: *Wild Salmon and Aquaculture in British Columbia* (2003)

Pacific Fisheries Resource Conservation Council: *The Salmon Aquaculture Forum: Discussion Paper on Practices & Findings* (2003)

Report of the Standing Committee on Fisheries and Oceans: *The Federal Role in Aquaculture in Canada* (2003)

Commissioner of the Environment and Sustainable Development's Chapter 5*: Fisheries and Oceans Canada – Salmon Stocks, Habitat, and Aquaculture* (2004)

Commissioner for Aquaculture Development's *Recommendations for Change* (2004)

DFO's Evaluation of the Program for Sustainable Aquaculture – *Project 2004-65143E – Final Advisory Report* (2004

BC Auditor General's Salmon Forever: *An Assessment of the Provincial Role in Sustaining Wild Salmon* (2004/2005)

An Audit of the Management of Salmon Aquaculture for the Protection of Wild Salmon in British Columbia (2006)

BC Special Legislative Committee on Sustainable Aquaculture Final Report (2007)

BC Pacific Salmon Forum Final Report & Recommendations to the Government of British Columbia (2009)

Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River (2012)

Report of the Senate Standing Committee on Fisheries and Oceans: *An Ocean of Opportunities: Aquaculture in Canada* (2015)

Appendix 9 — Council Member View on Risk — Perspective 1

Inclusion does not imply endorsement by council

Appendix 9 – Council Member View on Risk — Perspective 1

It was noted in Section 4 of this report that MAACFA members agree that risk to wild salmon populations presented by salmon net-pen aquaculture is the primary overarching issue and managing risk is the basis for developing our advice.

In this appendix Tony Allard elaborates on the perspective of risk, summarized as Perspective 1 in the MAACFA Final Report. His views are presented as submitted for inclusion in the Report's appendices, for information and this does not imply endorsement by council.

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The Case for Caution – Executive Summary

Based on the level of risk of harm to the environment, First Nations' concerns and the potential for significant economic loss, we believe this is an important opportunity for the Minister of Agriculture to be the first in a very long time to stand up for wild Pacific salmon and to align B.C. with the established and emerging trends in both environmental and Indigenous law.

Giving consideration to the Council's mandate and the Case for Caution set out in this Appendix, we recommend that the Council's advice to the Minister encourage her to:

1. Acknowledge that British Columbians have a very low tolerance for putting wild salmon at risk, and accept that the science on impacts such as sea lice and pathogen transmission, combined with statistical data which strongly suggests that salmon which pass by open net-pen farms fare substantially worse than those which do not, confirms that open net-pen farms pose more than a minimal risk of serious harm to wild salmon and to the environment.

2. Urge Premier Horgan and his Cabinet to announce that the Province will not renew existing tenures and will not issue new tenures for marine finfish salmon farms using open net-pens on the basis that they are not socially and ecologically sustainable.

3. Call on the Federal Government to increase oversight and public transparency in compliance with conditions of licences and the management of existing farms in the interim, including a prohibition on the transfer of PRV-infected smolts to open net-pens.

4. Commit to the development and implementation of a plan to transition (and sustainably grow) British Columbia's aquaculture industry to closed containment by a set date (i.e. 2025).

5. Recognize the future risks from climate change and other environmental factors outside of our immediate control, and commit to investing in habitat restoration to further protect B.C.'s wild Pacific salmon and support sustainable, healthy, genetically diverse wild salmon populations that are more resilient to these risks.

These recommendations are based on the evidence and analysis supporting the conclusion that the risk of serious harm posed to wild Pacific salmon from open net-pen salmon farms is well beyond a minimal risk, and that the level of risk is far higher than what is required to conform to the precautionary principle, as required by law.

In our analysis, we find that Fisheries and Oceans Canada (DFO) has effectively abandoned its constitutional mandate to protect fisheries and oceans by, among other things, failing to adopt a precautionary approach in its regulation of open net-pen aquaculture, in order to promote and develop the salmon farming industry. Examples of this are:

- without explanation, departing from the International Standard for diagnosing Heart and Skeletal Muscle Inflammation (HSMI) in farmed Atlantic salmon, in favour of its own diagnostic approach – an approach that allows DFO to deny that HSMI has been present in B.C. salmon farms since at least 2011;
- failing in its 2016 management approach to the piscine orthoreovirus (PRV) to test Atlantic salmon smolts for PRV prior to transfer into open net-pens, contrary to the 2015 court decision in *Morton v. Canada (Fisheries and Oceans)* and its duty under the *Fisheries Act*; and
- failing to comply with s. 56 of the *Fishery (General) Regulations* by setting a risk threshold that only triggers harm reduction at a threat of species-level extinction.

In light of DFO's actions contrary to the prevailing science and the law with respect to its duty to protect wild salmon, it falls to the B.C. Government to do what is best for British Columbia. This accords with the broad authority under s. 11 of British Columbia's *Land Act* to dispose of Crown land only if the Minister considers it advisable in the public interest. It also accords with the emerging case law that requires the Minister to consider whether granting tenures for finfish aquaculture is consistent with the precautionary principle's requirement to anticipate and prevent potential environmental degradation or irreversible damage.

Further, Canada's Constitution requires the B.C. Government to respect First Nations' rights. The First Nations Fisheries Council of B.C.'s resolution not to support open net-pen salmon farms, and the occupation of salmon farm facilities in 'Na̲mgis and Musgamagw territories, demonstrates that there is a significant level of First Nation opposition to open net-pen aquaculture. Allowing farms in First Nation territories without the consent of those Nations also violates the United Nations Declaration on the Rights of Indigenous Peoples. First Nations who rely on wild salmon that migrate near open net-pens are also impacted and must have their constitutional rights respected.

Our assessment of the level of risk is based on considering the cost of harm and the probability of harm occurring. In evaluating the potential cost of harm, we find that the full ecological, cultural and economic cost of a catastrophic loss of wild salmon is incalculable. In such circumstances, it follows that the risks to wild salmon of using open net-pens to raise farmed salmon must be extremely low to be acceptable.

Even if the decision is based solely on economics, the wild salmon economy is a greater driver of economic prosperity in B.C. than is the aquaculture industry. It provides British Columbians with 42% more jobs than aquaculture and contributes 26%, or $145.8 million, more to British Columbia's GDP annually. Importantly, it is the open net-pen aquaculture industry that poses a threat to the viability of the wild salmon economy, not the other way around. The risk of further damaging the wild salmon economy is not worth taking. Certainly not until the lack of harm to wild Pacific salmon is proven by the aquaculture industry.

Evidence presented to the Cohen Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River (Cohen Commission), and the published science since that time, provides compelling evidence that the probability of significant harm is more than minimal, including:

- Dr. Rosenau's analysis in his presentation to Council, and that of other researchers, shows very good evidence that salmon passing close to open net-pens have substantially worse survival rates than those which do not;
- Dr. Dill's presentation to Council that risks to wild salmon from sea lice amplified by open net-pens are "unambiguous and substantial"; and
- research by Dr. Miller and others that shows while we do not yet have a complete picture of the impacts on wild Pacific salmon from high levels of exposure to PRV, the available evidence strongly supports a conclusion that the level of risk is high, warranting both caution and urgent further investigation.

Dr. Miller reported to Council that PRV-associated disease symptoms of HSMI and jaundice syndrome are present on B.C. Atlantic salmon and Chinook salmon farms, respectively. There is also published research finding that a PRV-like virus associated with HSMI-like symptoms has been confirmed in farmed Coho in Chile. The Strategic Salmon Health Initiative (SSHI) recently published a finding of correlational evidence that PRV is the one virus in common for the Chinook salmon farm (Creative Salmon) in B.C. and the Coho farm in Chile, and in a similar disease outbreak in Rainbow Trout in Norway. Japanese researchers have also found a cause and effect relationship between PRV-2 and a disease they call erythrocytic inclusion body syndrome (EIBS), which is highly similar to the jaundice/anemia and HSMI diseases described in B.C. Chinook salmon, Chilean Coho and Norwegian Rainbow Trout.

This evidence supports the conclusion that the risk associated with PRV is more than sufficient to trigger the legal requirement to apply the precautionary principle. This is especially so in light of the Committee on the Status of Endangered Wildlife in Canada's recent recommendation to the Federal Minister of the Environment that eight of the 24 Fraser River sockeye populations be declared endangered, and a further seven declared threatened or of special concern.

Further, Council was told that SSHI has identified several novel viruses yet to be thoroughly studied, and that the cause of the "mortality related genomic signature" discussed in the Cohen Commission proceedings which appears to have seriously disrupted Fraser River sockeye runs has still not been identified. Whether or not offending viruses originate naturally or in fish farms is immaterial. High rearing densities in fish farms act as bio-amplifiers, which present these contagious viruses (and sea lice) in breathtakingly large numbers to passing smolts heading out to sea and to adult fish returning to spawn.

The root of the problem is the inability of open net-pen farms to capture and control waste combined with the free flow of parasites and pathogens between the farms and the marine environment. As Dr. Dill said in his presentation to Council:

> *Unlike Las Vegas, what happens in the pens doesn't stay in the pens.*

Attempting to respond to risk by addressing simple, short-term objectives in a "harm reduction" approach suggests that the problem the aquaculture industry is facing is one of public perception and that perception can be managed by easy, short-term solutions that avoid significant regulatory reform. This approach mistakes cause for effect. Lack of public trust is not the cause of the aquaculture industry's problems. Lack of public trust is what we get when the regulator fails to adequately manage risk. Where it advocates for short-term objectives to sway public perception, the Council's Report is protecting the failing status quo at the expense of wild salmon.

Given the level of risk, we believe the only way to build trust is through reform of the regulation of the industry. That reform begins with the regulator following the science and the law and by ceasing to issue licences that introduce and transfer PRV-infected smolts into open net-pens until it can be shown that wild Pacific salmon are not impacted. This puts the burden of proof squarely where it should be – on the regulator and the industry. That reform continues by acknowledging that the risks presented by open net-pens, which require regular flushing to operate, cannot ever be adequately mitigated and continues further by embracing a transition to closed containment.

We do not accept any assertion that because there are other stressors impacting wild salmon that are much more difficult to control (such as climate change) that we should give up on controlling the stressors within our control, particularly given the Council on the Status of Endangered Wildlife's recognition of the fragility of wild salmon.

While reducing the risk of harm to wild salmon does not require that an alternative be available before harmful practices are halted, we do not believe it needs to be an either/or scenario – healthy populations of wild Pacific salmon or a successful aquaculture industry. Emergent closed containment aquaculture removes the risk of open net-pen aquaculture to wild salmon. Council heard that the open net-pen industry has evolved over the past 30 years. Published reports show that advancements in land-based closed containment technology are coming on stream faster than anticipated, with optimization, standardization and scale improving the economic feasibility, making closed containment technology the logical continuation of that evolution. While acknowledging that innovation typically occurs over several iterations, the risk of harm dictates that the transition in B.C. must begin now as closed containment technology provides B.C. with the best chance of protecting wild Pacific salmon and of taking advantage of the economic opportunity for sustainable aquaculture.

Last but not least, we must learn from the devastating demise of Canada's northern cod stock. With the benefit of hindsight, the demise has been shown to have resulted largely from regulatory mismanagement. DFO failed to acknowledge risk. DFO was willing to ignore uncertainty and interpret data optimistically. It squashed other viewpoints. By doing all this, DFO was able to hold that decisions were based on science when they were not. At the time, DFO blamed environmental factors outside of their control, though it became increasingly clear these factors played only a minor role in the destruction of the stock – all in the name of protecting jobs and the economic interests invested in the status quo, all of which were ultimately lost and may never be recovered.

The only good that can come from the loss of northern cod is to learn from it and make sure that it never happens again. Thus, in response, in 1996 Canadians entrenched the precautionary principle in Canada's *Oceans Act*. British Columbians expect the Minister and DFO to follow it and will accept no less for wild Pacific salmon.

It is on this basis that we make the recommendations set out in this Case for Caution.

The Case for Caution – Introduction

> ***There is a risk that DFO will not proactively examine potential threats to migrating sockeye salmon from salmon farms, leaving it up to other concerned parties to establish that there is a threat. – Mr. Justice Bruce Cohen*** [11]

When Mr. Justice Cohen wrote those words, it seems likely that he was mindful of the events leading up to the closure of the northern cod fishery in Atlantic Canada in 1992, the greatest crisis ever precipitated by DFO, a turn of events that resulted in the virtual closure of that fishery for the past 25 years. The history of decisions leading up to the crisis makes interesting reading. As a result of mismanagement of northern cod, in Newfoundland alone over 35,000 fishers and plant workers from over 400 coastal communities became unemployed.[12]

We are struck by the similarity of the attitudes of senior DFO personnel prior to the cod crisis with those attitudes seemingly prevalent in DFO today regarding aquaculture management in B.C. It reminds us of Yogi Berra's observation that it looks like "déjà vu all over again," as we watch DFO risk precipitating a second crisis, this time along the coast and watersheds of B.C. at a time when many wild Pacific salmon species are at dangerously low population levels.

Our strong desire and responsibility to protect wild Pacific salmon emanates not just because of the cultural and economic benefits they provide, but also because they are a keystone species, transporting nutrients that support aquatic and terrestrial ecosystems at each stage of their lives.[13] This calls for taking extreme care because the demise of wild Pacific salmon would devastate the cultures, economies and species that rely on them.

In this Case for Caution, we set out the evidence that supports finding that the risk of harm posed to wild Pacific salmon from open net-pen salmon farms goes well beyond a minimal risk of serious harm. Furthermore, the cost of that risk in ecological, cultural and economic terms is so high that we believe the Council's advice to the Minister of Agriculture must state that this level of risk is unacceptable to British Columbians.

We thank former Minister Letnick for appointing us to this Council and Minister Popham for allowing our work to continue and for taking this issue and the accompanying heavy responsibility so seriously.

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[11] *The Uncertain Future of Fraser River Sockeye – Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River* (hereinafter "Cohen Commission"), Vol. 3 at p. 12.

[12] Lan Gien, "Land and Sea Connection: The East Coast Fishery Closure, Unemployment and Health," *Canadian Journal of Public Health* 91, no. 2 (2000): 121.

[13] See C.J. Cederholm, M.D. Kunze, T. Murota, and A. Sibatani, "Pacific Salmon Carcasses: Essential Contributions of Nutrients and Energy for Aquatic and Terrestrial Ecosystems," *Fisheries* 24, no. 10 (1999).

Participating in the deliberations of the Council has been a valuable experience – one that has forced us all to confront some strongly held views different from our own. Based on these deliberations and some independent fact-gathering, we set out below our analysis and conclusions. Some readers may disagree with what we have written. None of us has a complete body of knowledge about wild and farmed salmon. We welcome comments from any reader, particularly if buttressed by facts.

The Starting Point – What Is the Level of Risk in Open Net-Pen Aquaculture?

Council members expressed a shared vision of "sustaining wild salmon within a healthy ecosystem while recognizing the interdependence and importance of salmon to communities in B.C." and expressed a desire to provide advice that conforms with this broader aim.

From our perspective, achieving this vision must start with an assessment of the level of risk, which is a factor of the cost of the potential harm that open net-pen aquaculture may cause and the probability that harm will occur. Only then can we discuss whether the level of risk is acceptable to British Columbians.

As we undertake our analysis, we share parallels to a time when comparable ecological and economic costs were realized: the devastating demise of Canada's northern cod stocks. We do this with the goal of helping to ensure a better outcome for wild Pacific salmon.

In 1988, only a few years before Canada admitted that the northern cod fishery was in collapse, the official word was that all was well:

> The Department of Fisheries and Oceans prides itself on world-class scientific capability. The unprecedented rebuilding of the Northern Cod resource since 1977 is ample testimony to sound management practices based on good scientific advice. Having nurtured the resource to a good stage of health overall, the department is now setting out to enhance that all-important achievement by addressing more intensively and more comprehensively other problems in the fishery.[14]

By 1989, reality mocked DFO's optimism. By 1992, there were virtually no northern cod left and Canada announced a moratorium on commercial cod fishing. <u>By 1996, Canada had vowed never to let this happen again, passing the *Oceans Act*, which requires the Minister of Fisheries and Oceans to apply the precautionary principle to all matters within the Minister's jurisdiction.</u>

[14] Department of Fisheries and Oceans Newfoundland Region, "The Science of Cod, Considerations in the Scientific Study and Assessment of Cod Stocks in the Newfoundland Region," *Fo'c'sle* 8, no. 2 (February 1988): p. 29 final para.

The Cost of Harm

The enormous ecological and economic costs endured by the collapse of the cod fishery were caused, in part, by mismanagement. Repeatedly, Canada misidentified both the risks and the costs associated with those risks. Our government attempted to prevent short-term economic loss by protecting the economic interests vested in the status quo instead of embracing the fundamental change that was necessary:

> … the government established a pattern that it would follow until the cod stocks disappeared. Scientists would warn of serious stock declines and advise dramatic catch reductions; the government, afraid of throwing fishermen and processors out of work, would merely inch the TAC [total allowable catch] downwards. Its refusal to act quickly destroyed the cod stocks, and, with them, the jobs the government wanted so desperately to protect.[15]

As a result of this mismanagement, over 35,000 fishers and plant workers from over 400 coastal communities became unemployed in Newfoundland alone.[16] History shows that ignoring the warning signs, and blindly protecting the status quo, can ultimately result in the demise of the resource the status quo depended upon. We keep this example in mind as we consider a more responsible approach to the protection and preservation of the economic and ecological value of wild salmon.

The Value of Wild Salmon

Wild salmon are a keystone species of fundamental ecological importance. How does one put a price on the extinction of the keystone species on the Pacific coast of Canada?

Keeping in mind the fundamental ecological importance of wild Pacific salmon and the fact that British Columbians revere wild Pacific salmon because of their social and cultural benefits, the economic value of the wild salmon economy in B.C. currently exceeds that of the B.C.'s open net-pen salmon farming industry. Further, the restoration of habitat and rejuvenation of wild salmon populations represents an important opportunity (and constitutional responsibility) for reconciliation with First Nations and further economic growth.

Attachment 2 to this Appendix provides charts of the Economic Impacts of Pacific Salmon Fisheries prepared for the Pacific Salmon Commission (the "PSC

[15] Elizabeth Brubaker, *Unnatural Disaster: How Politics Destroyed Canada's Atlantic Groundfisheries* (hereinafter "Unnatural Disaster") at p. 18, https://environment.probeinternational.org/2000/01/18/unnatural-disaster-how-politics-destroyed-canadas-atlantic-groundfisheries/, accessed January 23, 2018.

[16] Lan Gien, "Land and Sea Connection: The East Coast Fishery Closure, Unemployment and Health," *Canadian Journal of Public Health* 91, no. 2 (2000): 121.

Report"). Over the period 2012 to 2015, the annual contribution of both the commercial and the recreational sectors to B.C. alone averaged:

- $703.6 million in Gross Domestic Product (converted from US$641 million in Attachment 2, based on page 61 of the PSC Report, which provides the annual impacts in Canadian dollars), and
- 9,450 full-time equivalent (FTE) jobs.

In comparison, Appendix 3 of the Council's Report relies on data from a recently released independent economic analysis of the salmon aquaculture industry in British Columbia that was conducted over three years. The Council's Report provides the following numbers for the best of those three years, 2016, a year that had record prices for salmon:

- the GDP generated by the B.C. farm-raised salmon industry (including processing) increased 36 percent to $557.8 million in Gross Domestic Product, and
- employment increased 33% to 6,610 FTE jobs.

Appendix 3 states that the increase for the salmon aquaculture industry over the past three years turned on record-high prices, which presumably also positively impacted the value of the commercial wild salmon fishery.

Without considering the monetary value of wild Pacific salmon to other industries such as tourism (over and above the recreational fishery included above), and the more important non-monetary values, it is evident that, from a purely economic perspective, the wild salmon economy holds significantly more value and more jobs for British Columbians than does open net-pen salmon farming.

Even when the economic contribution of wild salmon is averaged over four years (which did not include years with record-high salmon prices) and that averaged contribution is compared with the economic contribution of farmed Atlantic salmon in 2016 – a year with record prices for salmon – the economic contribution of wild salmon is significantly greater. Assuming that the PSC Report, and the report that the Council's Report relies on, both accurately and credibly represent the economic contributions of wild Pacific salmon and farmed Atlantic salmon, then the wild salmon economy provides British Columbians with 42% more jobs than aquaculture and contributes 26%, or $145.8 million, more to British Columbia's GDP annually. Wild salmon is a greater driver of economic prosperity in B.C. than the existing aquaculture industry. Most importantly, open net-pen aquaculture threatens the viability of the wild salmon economy, not the other way around.

<u>Reducing the risk of harm to wild salmon does not require that there be an alternative to open net-pen aquaculture available before harmful practices are halted</u>. However, the Council has acknowledged that the open-net-pen industry

has evolved over the past 30 years, and we view closed containment technology as the likely continuation of that evolution.

There is evidence that the production challenges and biological issues with open net-pen aquaculture, combined with the associated increase in production costs and regulatory constraints restricting growth of the industry using old technology, are accelerating the development of land-based salmon aquaculture technology. In 2015, the Norway Research Council and its industry partners invested US$25 million into the CtrlAqua research program, with the main goal being to develop technological and biological innovations that will make closed systems a more reliable and economically viable technology.[17] Council also heard from Norwegian researcher Ann-Magnhild Solås that Norway is using development licences as incentives for capital-intensive innovative projects that reduce environmental footprint.[18]

The DNB Markets Report, prepared by a division of Norway's largest bank, is clear that recirculating aquaculture systems (RAS) technology has advanced faster than anticipated.[19] Optimization, standardization and scale are starting to positively impact the economics, investor interest and commercial-scale adoption.[20] While recognizing that new technologies typically must go through several iterations of innovation, land-based, closed containment aquaculture is already technologically viable and, if not already, will very soon be economically viable at a large scale.

British Columbia has plentiful land with access to both fresh and salt water, existing infrastructure to support aquaculture, low-cost hydro power and access to the US I-5 corridor and Pacific Rim markets, which positions B.C. to take advantage of a trend toward land-based closed containment aquaculture and the growing demand in Canada, the U.S. and Asia for sustainably produced seafood. The DNB Markets Report and industry media show that European land-based salmon farming companies are beginning to move into the U.S. with plans for large commercial-scale farms,[21] thus B.C. may need to respond quickly to the opportunity before it is lost to the U.S.

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[17] See https://nofima.no/en/prosjekt/ctrlaqua/, accessed November 14, 2017.

[18] See Slide 16 of Ann-Magnhild Solås's presentation to Council for a description of Norway's development licences.

[19] See Appendix 8, Attachment 1 of the Council's Report for the Executive Summary of the DNB Markets Report *Deep Dive into Land-Based Farming* (February 1, 2017). The full report is at http://www.kuterra.com/files/1314/9669/9783/DNB_-_Deep_dive_into_land-based_farming.pdf, accessed November 17, 2017.

[20] See Appendix 8, Attachment 2 of the Council's Report for a list of planned and operating RAS Atlantic salmon production, as at 2017 per the Conservation Fund's Freshwater Institute.

[21] See the DNB Markets Report, supra., for an overview of the phases of Denmark's Atlantic Sapphire project under development in Miami, Florida. See also Neil Ramsden, "Nordic RAS Specialist Establishes US Subsidiary," *Undercurrent News* (January 9, 2018), https://www.undercurrentnews.com/2018/01/09/nordic-ras-specialist-establishes-us-subsidiary/, accessed January 21, 2018.

Hidden Costs Borne by the British Columbia Taxpayer

With open net-pens, there is no mechanism to control wastes and potentially hazardous substances that are flushed from open net-pens directly into the marine environment. Thus, British Columbians incur the ecological and biological costs, and wild salmon are put at risk. Land-based, closed containment aquaculture carries greater upfront capital costs, but the investment in new clean technology ensures that inherent risks caused by free-flowing waste from open net-pen aquaculture are avoided. RAS technology captures and controls waste, sea lice are avoided, and pathogens and pollutants from farmed fish do not interact with the marine environment.

B.C. currently grants ocean tenures, a public resource, at a very low cost to industry. The total annual rent collected by B.C. on <u>all finfish aquaculture tenures</u> for fiscal 2016/2017 was $1,953,295.[22] Assuming approximately 119 tenures (113 marine finfish tenures per Appendix 3 of Council's Report), we estimate that the annual lease payments for a tenure in B.C. at $16,414, with a present value of lease payments in perpetuity calculated to be in the $700,000 range.[23]

In comparison, in 2014, Norway last auctioned off a new, freehold open net-pen site for over Cdn$10 million, while adopting a policy that licenses sites for land-based, closed containment systems for free to incent research and development of alternatives. The policy used by Norway aims at ensuring that industry does not externalize the cost of its pollution, pathogens and parasites and that such costs are not borne by the taxpayer.

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[22] In an email dated Friday, May 26, 2017, James Mack advised: "FLNRO [B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development] has provided that the total annual rent collected on finfish aquaculture tenures for fiscal 2016/2017 was $1,953,294.80. This is for <u>all</u> finfish, and therefore includes tenures culturing species other than Atlantic salmon, including the few lake aquaculture sites that are active." In contrast, the cost of a tenure in Norway is much more expensive; DNB Markets Report at p. 25 states that the last new licence made available for a new open net-pen site in Norway was in 2014, and it sold for approximately NOK66m, or approximately Cdn$10m.

[23] To compare the tenure cost of finfish farms in B.C. (rental) and in Norway (purchase of the site), it is helpful to calculate the present value of future annual rental costs. From the available data on tenure revenue in B.C. set out in the endnote above, and assuming 119 farm sites, the present value of the cost of an open net-pen aquaculture tenure in Canada, in perpetuity is estimated in Canadian dollars as follows:

> Monthly payment: $1,368 Annual payment: $16,414
>
> Present value:
> Use as Discount Rate the 30-year Canadian bond rate (2.385% at January 11, 2018) is $688,218 or the 10-year bond rate (2.20 % at January 11, 2018) is $746,091.

Each farming company will have its own cost of capital and this will very likely be higher than the "risk free" government bond rate so the appropriate discount rate will be higher than the one used here (actual cost of capital) and therefore the resulting present value of the tenures in B.C. will be lower.

Assuming tenure rentals in B.C. at perpetuity, the cost is less than 10% of the cost of a new open net-pen site in Norway. Thus, it is understandable why the industry would not want to pursue closed containment in Canada. To encourage the adoption of closed containment technologies, Canada should at least level the playing field for the economics of closed containment aquaculture by charging tenure fees that more closely represent the cost of the use and inevitable degradation of the public resource.

Industry's unwillingness to evolve to a more sustainable technology here in B.C., which would protect our marine environment (including wild salmon), appears more grounded in financial self-interest, than in the economic or ecological interests of British Columbians. We should not expect industry to change its practices here until there is a cost associated with failing to do so.

Ecological Costs

Most importantly, the ecological cost of endangering wild salmon is incalculable. As a keystone species, wild salmon transport nutrients that support aquatic and terrestrial ecosystems at each stage of their lives.[24] Thus, the full cost of a catastrophic loss of wild Pacific salmon simply cannot be calculated.

Dr. Brian Riddell best summed this up in his presentation to Council:

> ... of all the salmon aquaculture-producing countries of the world, it should be expected that British Columbia would have the greatest concern for potential impacts on wild salmon given the diversity and wide spread geographic distribution of our salmon, and their high ecological and human importance (culturally and economically).[25]

The Probability of Harm

Aquaculture poses inherent risks to wild salmon, with sea lice and pathogen transmission being two of the most dangerous risks. Adequate risk assessment and management practice require an accurate assessment of the danger of inherent risks, followed by effective mitigations and controls to either eliminate the probability of those risks materializing or reduce that probability to an acceptable level. Such risk assessment and management cannot be undertaken without first accurately assessing the gravity of the inherent risks.

Unfortunately, DFO has a long history of ignoring the gravity of the risks:

> DFO routinely suppressed politically inconvenient research into the causes of the cod decline. An internal government report, based on meetings with almost every member of DFO's Science Branch in 1992, charged that "Scientific information surrounding the northern cod moratorium, specifically the role of the environment, was gruesomely mangled and corrupted to meet political ends." It noted that the department routinely gagged its scientists, leaving communication with the public to ill-informed spokespersons. "Management is fostering an attitude of scientific deception, misinformation and obfuscation in presenting and defending the

[24] See C.J. Cederholm, M.D. Kunze, T. Murota, and A. Sibatani, "Pacific Salmon Carcasses: Essential Contributions of Nutrients and Energy for Aquatic and Terrestrial Ecosystems," *Fisheries* 24, no. 10 (1999).
[25] See the summary of Dr. Brian Riddell's presentation to the Council in Appendix 5 of the Council's Report.

> science that the department undertakes and the results it achieves," the report said. "It appears that science is too much integrated into the politics of the department … <u>It has become far too convenient for resource managers and others to publicly state that their decisions were based on scientific advice when this is clearly not the case</u>"[26] [emphasis added].

Every indication is that DFO continues to avoid and suppress science that is contrary to the status quo. As recently as November 30, 2016, Dr. Miller, a leading scientist with DFO, said the following before the Standing Committee on Fisheries and Oceans:

> It is also important that as regulators, we are not afraid to ask questions and conduct research that may unearth findings that are not immediately convenient to industry and may require us to rework policies to ensure minimal risk.
>
> When I started down this path of research in 2012, I was told by an upper manager, who's no longer with the department, that it was irresponsible to ask research questions that could potentially result in negative economic ramifications on an industry if we did not already know the answer. At the time, my lab was developing very powerful technology that could simultaneously quantitate 47 different pathogens – viruses, bacteria, and fungal parasites – in 96 fish at once … The manager was concerned that by employing this technology, we would make our salmon in B.C. look dirty, and impact their economic value in the market, and that if we uncovered agents that were not known to be endemic, ENGOs and the public would immediately point to the aquaculture industry as the culprit. As such, the attitude was don't look closely, especially for things that we didn't know already were there.
>
> …
>
> At a working level, I remain concerned that there is continued reluctance by scientists, veterinarians, most of whom have strong ties to the industry, and managers to ask questions and undertake research that might not turn out favourably for the industry.[27]

The probability of harm cannot be sufficiently reduced if the regulator "whistles past the graveyard," steadfastly avoiding acknowledging or investigating the risks and the harm posed. In the cod era, we were wrong and arrogant and reckless until after it was too late, and so, as discussed below, we took action to make sure

[26] Unnatural Disaster, supra. at p. 5.

[27] Standing Committee on Fisheries and Oceans, Number 038, 1st Session, 42nd Parliament, Wednesday, November 30, 2016.

it never happened again by entrenching the precautionary principle in the *Oceans Act*.

Evidence of Salmon Farming Reducing Survival of Wild Salmon

Despite the difficulties associated with collecting evidence on the effect of fish farms on wild fish, strong scientific evidence demonstrates that salmon passing close to open net-pens have substantially lower survival rates than do those that do not pass close to the farms.

In a 2008 paper entitled "A global assessment of salmon aquaculture impacts on wild salmonids,"[28] the authors found a significant reduction in marine survival of salmonids in areas with salmon farming compared to areas without farms in Scotland, Ireland and Atlantic and Pacific Canada:

> ... we show a reduction in survival or abundance of Atlantic salmon; sea trout; and pink, chum, and coho salmon in association with increased production of farmed salmon. In many cases, these reductions in survival or abundance are greater than 50% [per generation].[29] Meta-analytic estimates of the mean effect are significant and negative, suggesting that salmon farming has reduced survival of wild salmon and trout in many populations and countries.

The authors go on to state that:

> Populations in which juvenile salmonids pass by salmon farms during their migration were considered to be exposed to impacts of salmon farming. Exposed populations were carefully paired with control populations in the same region whose migrations did not lead past farms, but which otherwise experienced similar climate and anthropogenic disturbances. Use of such paired comparisons allowed us to control for confounding factors such as climate to detect population level impacts.

The authors add that:

> ... the comparisons in British Columbia include large numbers of rivers (> 80 rivers in each case), so differences in anthropogenic effects would have to hold over many watersheds to explain the effects we estimate.

In B.C., we have not acted on such findings, even in a precautionary way. Instead, Dr. Gary Marty, Senior Fish Pathologist for the Government of B.C.'s Animal

[28] This paper by Jennifer S. Ford and Ransom A. Myers appeared in *PLOS Biology* 6, no. 2 (February 2008).
[29] The losses tended to be greater where both the farmed and the wild salmon were Atlantics. The losses for wild Pacific salmon were generally in the range of 10-50% per generation.

Health Centre, has favoured contrary findings as reported by Torrissen et al., who compared changes in wild salmon catches for countries with and without open net-pen farms and found little difference.[30] However, this paper by Torrissen et al. invites the criticism that in the countries included in the study, permitted salmon catches are under government control and do not necessarily correlate well with actual salmon returns. Perhaps more importantly, the study did not pair and compare samples that had similar conditions for variables such as climate and water temperature. The reliance on the paper by Torrissen et al. is typical of DFO's pattern of favouring science that supports its aims at the expense of science that is contrary to its regulatory approach.

Given this practice by DFO, we believe it is important to bring forward some of the science that DFO is not acting on. In two papers published in 2012 and 2015, Ruggerone and Connors, and their collaborators, reported a negative correlation between sockeye salmon survival and the number of farmed salmon that wild Fraser sockeye migrate past early in life.[31]

Lastly, in March 2017, Dr. Marvin Rosenau, of the Fish Wildlife and Recreation Program at BCIT, appeared before the Council. Dr. Rosenau analyzed a wealth of B.C. salmon abundance data from the past 30 years and presented the results in 74 overheads, two of which are reproduced below.

Figure 1 (Slide 2 of Dr. Rosenau's presentation to the Council) graphs the number of returns per spawner for Fraser River sockeye. The precipitous drop in abundance after 1992 is clearly visible. This marked drop in salmon abundance coincides with the introduction of open net-pens in British Columbia. Unlike other historical drops in productivity of Fraser River salmon, the decline that began after 1992 has not been followed by any significant sustained increase in productivity.

[30] O. Torrissen, S. Jones, A. Guttormsen, F. Asche, T.E. Horsberg, O. Skilbrei, D. Jackson, F. Nilsen, and P.A. Jansen, "Sea Lice – Impacts on Wild Salmonids and Salmon Aquaculture," *Journal of Fish Diseases* 36 (2013): 171.

[31] G.T. Ruggerone and B.M. Connors, "Productivity and Life History of Sockeye Salmon in Relation to Competition with Pink and Sockeye Salmon in the North Pacific Ocean," *Canadian Journal of Fisheries and Aquatic Sciences* (2015), doi:10.1139/cjfas-2014-0134; and B.M. Connors, D.C. Braun, R.M.M. Peterman, A.B. Cooper, J.D. Reynolds, L.M. Dill, G.T. Ruggerone, and M. Krkosek, "Migration Links Ocean-Scale Competition and Local Ocean Conditions with Exposure to Farmed Salmon to Shape Wild Salmon Dynamics," *Conservation Letters* (2012): 1.
The two references and the description of the negative correlation are contained in the critique of a document prepared by Dr. Gary Marty providing "Information Regarding Concerns about Farmed Salmon-Wild Salmon Interactions." The critique is co-authored by eight researchers affiliated with four Canadian universities: L.M. Dill, M. Krkosek, B.M. Connors, S.J. Peacock, A.W. Bateman, R. Routledge, M.A. Lewis and J. Reynolds. Neither paper was formally published. Both are available on request in electronic form from Wild Salmon Forever.

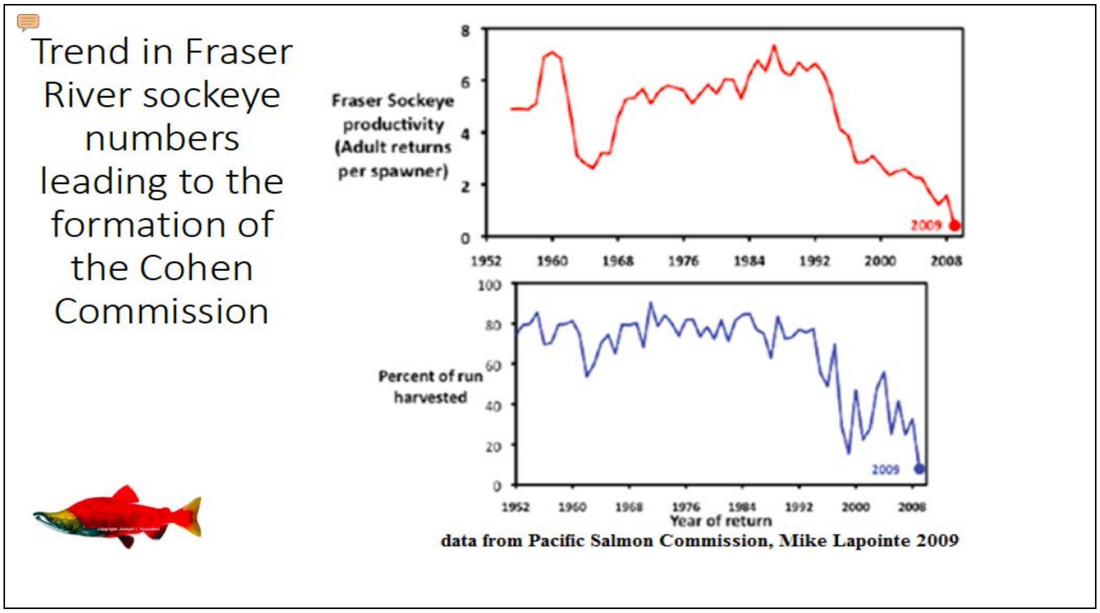

Figure 1 – Trend in Fraser River sockeye returns to spawn 1952-2009

The second graph on the overhead shows the percentage of the run that was harvested. Not surprisingly, that graph too shows a steep decline after 1992.

Figure 2 (a reproduction of Slide 72 from Dr. Rosenau's Briefing to the Council) shows an averaged rate of decline of several different runs of wild salmon as well as the ramp up of fish farm production.

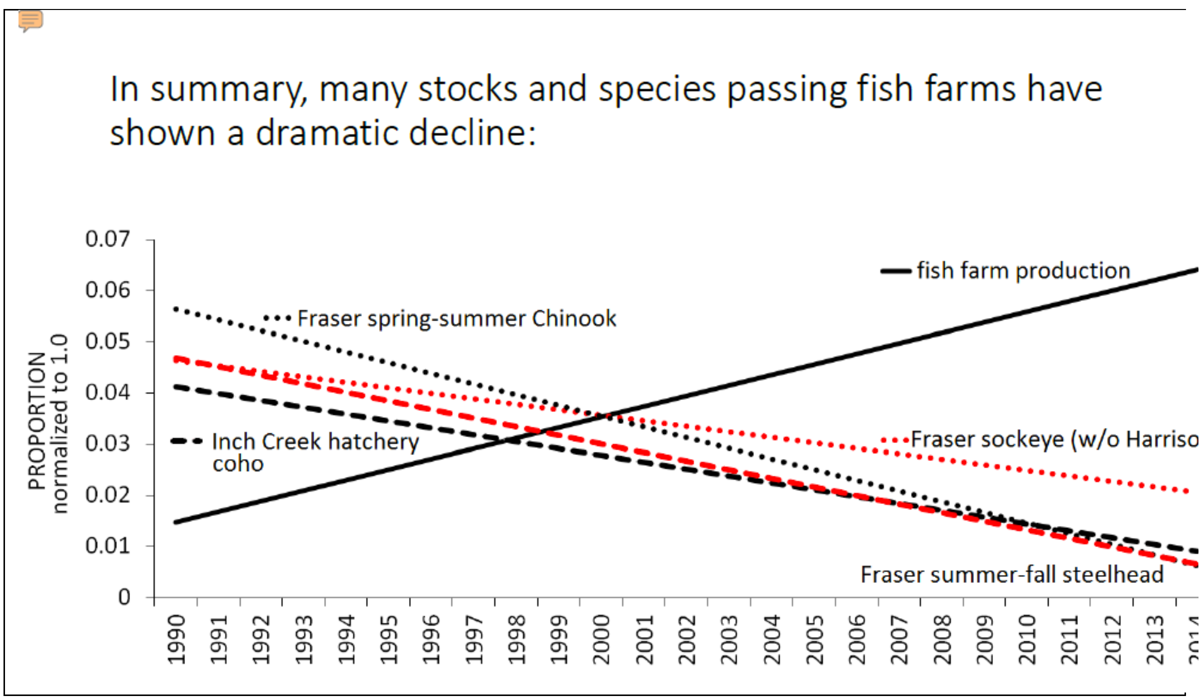

Figure 2 – Chart showing the decline of Fraser River salmon stocks 1990-2014

Dr. Rosenau's two major conclusions (reproduced from Slide 73 of his briefing to the Council) were as follows:

1. Multiple lines of evidence strongly support the conclusion that where juvenile salmonids migrate through areas of concentrated fish farms in south-western British Columbia, there have been large-scale collapses over many different species and populations, including the Gulf of Georgia, Fraser River and some west coast Vancouver Island watersheds.

2. This decline in salmon abundance has been the most catastrophic aquatic ecosystem collapse in the history of British Columbia, and the evidence points to the proliferation of fish farms, in timing and location, in south-western British Columbia.

The refereed papers cited here, combined with the Rosenau presentation, constitute an impressive body of evidence that points to open net-pen aquaculture being a likely contributor to the drastic decline in salmon abundance in south-western B.C. In the face of this precipitous 25-year decline in productivity, which Fraser River salmon have still not reversed, a harm reduction approach is hardly a sufficient response.

The next two sections consider research into two inherent risks from open net-pens – sea lice and pathogen transmission – that are implicated in causing this decline.

Sea Lice

Science has now confirmed that open net-pen salmon farms can cause unacceptable levels of sea lice transmission to wild salmon smolts.

Dr. Dill addressed the sea lice problem in his presentation to Council and in a report prepared to update the scientific literature published in refereed journals since the Cohen Commission (the Dill Report, provided as Attachment 1 to this Appendix).[32] His findings were supported by refereed journals and concluded that the sea lice problem alone is enough reason for B.C. to discontinue use of open net-pen farming:

> The risk to wild salmon from sea lice produced in Open Net Pens (ONPs) is unambiguous and substantial. Lice have been shown to reduce productivity of both wild pink and coho salmon populations in the Broughton Archipelago, and there is no reason to think they are not having similar effects elsewhere on the BC coast. The mechanisms by which lice impact individual survival are well understood, and these individual and population level effects have

[32] Included here as Attachment 1: *The Risks of Open Net Pen Salmon Farms to Wild Pacific Salmon: Summary of Scientific Findings* (hereinafter "Dill Report"), a report prepared for Wild Salmon Forever by Lawrence M. Dill, PhD FRSC, Professor Emeritus, Simon Fraser University, November 8, 2017.

been found consistently throughout the world and are supported by large-scale experiments.[33]

The evidence on the risk of sea lice associated with open net-pen farming presented to the Council, especially when viewed in the context of the sea lice problems in other jurisdictions, notably including Norway, is very strong. In her presentation, Norwegian researcher Ann-Magnhild Solås told Council that the Norwegian Scientific Advisory Committee for Atlantic Salmon estimated the annual loss of wild salmon to Norwegian rivers due to salmon lice at 50,000 adult salmon for the years 2010-2014, corresponding to an annual loss of 10% of the total pre-fishery abundance of wild salmon due to salmon lice. In a January 2018 report released by the Norwegian Institute for Nature Research, the authors reported that:

> … lice-induced mortality in farm-intensive areas can lead to an average of 12-29% fewer adult salmon … Mortality of sea trout [similar to steelhead in B.C.] is likely to be higher than in Atlantic salmon, because unlike the ocean-migrating Atlantic salmon, they usually remain in coastal waters, where fish farms are situated.[34]

These losses occur despite Norway's much stronger regulation of sea lice in their open net-pen farms.

Figure 3 (which is Slide 10 of Ann-Magnhild Solås's presentation to the Council) cites Forseth et al. (2017) as finding that in Norway salmon farming (through escapes, sea lice and infections) was the largest threat to wild salmon among those human impacts that we can do something about:

[33] Dill Report, supra. at p. 1.

[34] Eva B. Thorstad and Bengt Finstad, "Impacts of Salmon Lice Emanating from Salmon Farms on Wild Atlantic Salmon and Sea Trout, 2018" NINA [Norwegian Institute for Nature Research] Report 1449: 1, https://brage.bibsys.no/xmlui/handle/11250/2475746.

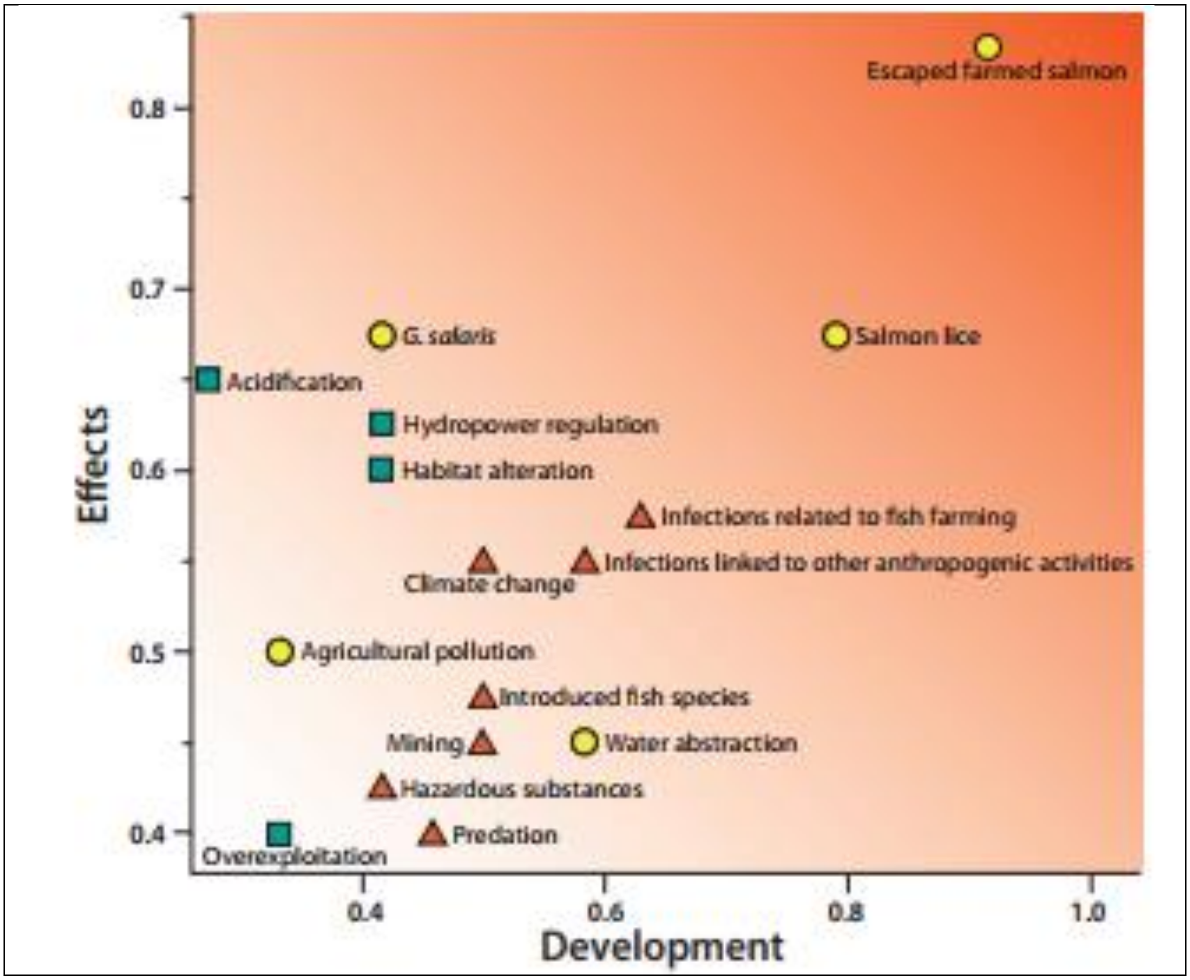

Figure 3 – Chart showing the threats to wild salmon in Norway

Not surprisingly, the biological challenges posed by sea lice are driving Norway to restrict growth and seek alternatives. Meanwhile, in our view Council let DFO and the industry "off the hook" with a theoretical presentation of regulation and farm management, without evaluating the actual practice. If it had, the Council would have found that the theory does not always match the reality.

With regard to sea lice, Council was told:

> In terms of sea lice management, the regulatory threshold set by DFO is three sea lice (*L. salmonis*) per salmon. If this number is exceeded on a farm between March 1 and June 30, the farm is currently required to initiate a management response that can include harvesting fish (to reduce the total number of sea lice) or therapeutic treatment of salmon. The number of wild, out-migrating juvenile salmon carrying a sea louse varies considerably year by year and by geographic location. Returning salmon, carrying sea lice from their ocean migration, have been known to become a source of sea lice in the

autumn months, and annual trends in the rise and fall of sea lice numbers on net-pen farm salmon are predictable.[35]

There is debate about whether the regulatory threshold set by DFO is sufficient to safeguard wild salmon and debate over how that threshold is enforced.

In the well-researched Broughton Archipelago, the salmon farming industry engaged in lice treatments prior to the juvenile wild salmon out-migration, and for a period of time this appeared to successfully lower the number of sea lice per wild salmon. However, beginning in 2015 sea lice levels on wild salmon increased once again.[36] The salmon farms in the area of this research were recently approved for a near tripling of the number of fish per farm. Sea lice limits per fish were not lowered to suppress the overall sea louse population in each farm.

In B.C., farms currently operate with little mandated real-time transparency in farm management data, in stark contrast to Norway where the industry is required to publicly post information about sea lice infestations every week. When data is reported, we see significant non-compliance and disregard for out-migrating salmon smolts. For example, from DFO-published data two farms in the Nuchalitz Inlet (near Zeballos), Steamer and Esperanza, reported excessive sea lice levels that persisted during sensitive periods for out-migration of juvenile salmonids.[37] Steamer first reported excessive levels (14.5 per fish) in September 2016 and continued to note "alternative management action" planned or underway, while its lice levels rose from 25 in January 2017 to over 33 at the beginning of the sensitive period in March. By May, its harvest had not been completed and had only reduced lice levels to 15 per fish – five times the management trigger. No count was provided for June. Esperanza first reported excessive lice in July 2016 and then stopped reporting counts "due to environmental conditions" until November, when it reported levels of 10; "alternative management action" was "planned" but not undertaken, while levels soared to over 48 per fish by February 2017. That farm entered the sensitive period with levels at 39.82, and still only "planning" management action. The farm began to harvest in April but was unable to bring lice levels below the management target until harvest was completed in August. Taking six or more months, including at least three months of the sensitive out-migration period, to remedy these high levels of sea lice is unacceptable.

There is also a significant gap in DFO's monitoring program, as it does not monitor sea lice levels on out-migrating juvenile salmon passing through areas with open net-pen farms. Monitoring of wild salmon for sea lice loads is of critical importance because some species of juvenile wild salmon, such as pink and

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[35] See Appendix 3 of the Council's Report.

[36] See Andrew W. Bateman, Stephanie J. Peacock, Brendan Connors, Zephyr Polk, Dana Berg, Martin Krkošek, and Alexandra Morton, "Recent Failure to Control Sea Louse Outbreaks on Salmon in the Broughton Archipelago, British Columbia," *Canadian Journal of Fisheries and Aquatic Sciences* 73 (2016): 1164, doi:10.1139/cjfas-2016-0122 .

[37] The 2016 and 2017 sea lice counts for both farms are available at http://open.canada.ca/data/en/dataset/3cafbe89-c98b-4b44-88f1-594e8d28838d, accessed January 4, 2018.

chum, passing the farms may weigh less than a gram in the early spring and thus are much more susceptible to impact.[38] Data was not provided to Council on the number of out-migrating juvenile salmon carrying a sea louse – just as stated above that it "varies considerably year by year and by geographic location." This level of ambiguity is, at best, unhelpful. Given the significant risk that sea lice from open net-pen farms pose to wild salmon, the relevant regulation lacks both the transparency and the efficiency required to address the harm posed.

Pathogen Transmission

This section considers the impacts of pathogen transmission from open net-pen farms to wild salmon, and the failure of the current management approach to pathogen transmission to reduce the risk. In this section we set out the evidence that:

- Industry and the regulator have ignored the trajectory of the science on pathogens such as PRV.
- The regulator adopted its own science, sometimes co-authored and funded by industry, when it served preserving the status quo. The regulator's approach to the diagnosis of HSMI is the most telling example.
- The regulator is openly defying the law requiring it to apply the precautionary principle to minimize harm.
- The regulator is erroneously setting risk thresholds that can only be triggered when there is the threat of extirpation of entire wild salmon populations or the sterilization of the ecosystems on which they depend.

The Science on Pathogen Transmission

Through the work of the Council, we have found that the emerging science regarding the transmission of disease from farmed to wild salmon is sufficient to call for extreme caution.

The Cohen Report, published in October 2012, provides the following paragraphs concerning the state of knowledge about salmon pathogens at that time, including a finding of at least some risk (and not accepting a quantification of low risk) posed from disease on salmon farms:

> The potential risk of disease spreading from farmed to wild salmon and how to describe that risk is the main difference between Dr. Dill and Dr. Noakes, and one on which other witnesses also commented. Of all the expert witnesses I heard from, no one told me there is no risk to sockeye; indeed, some said the risk could never be "zero," and others told me that salmon farms do increase the risk when compared with no salmon farms. Those (like Dr. Noakes) who ventured to quantify the risk told me it was "low" as a result of

[38] As discussed previously, Mr. Justice Cohen recognized this risk. See Cohen Commission, supra., Vol. 3 at p. 12.

> proactive policies and practices. Others (like Dr. Dill) did not believe the state of information was such that the risk could be quantified and said that disease on salmon farms could not be ruled out as posing a significant threat to Fraser River sockeye.
>
> I accept the undisputed evidence that there is some risk posed to wild Fraser River sockeye salmon from diseases on salmon farms. I also accept that management practices are intended to reduce that risk as much as possible and aim to keep both farmed and wild fish healthy. I agree with Dr. Noakes that the current regulatory data collected for the salmon-farming industry need to be maintained and that future work should focus on understanding diseases in wild fish. However, I am unable to agree with him that salmon farms pose a low risk to wild sockeye: I cannot make that determination on the evidence before me. I accept the evidence of Dr. Josh Korman, author of Technical Report 5A, Salmon Farms and Sockeye Information, and Dr. Dill that scientists need at least another 10 years of regulatory data before they can find relationships (if they exist) in the data.[39]

The Council's Report is being issued just over five years after the report of the Cohen Commission. We acknowledge that gaining an understanding of the factors affecting wild salmon abundance is difficult, but through the hard work of good scientists our knowledge has progressed. To illustrate this point, Attachment 3 to this Appendix provides a timeline for the research conducted to understand the fish health impairment potential of PRV.

Valuable new tools have also been added to the research arsenal, including rapid and low-cost techniques for the analysis of DNA and RNA, which can be focused on fish pathogens as well as on the fish themselves. With one small tissue sample clipped from a fish gill it is possible to determine not only the species of fish, but also where it was hatched and, most importantly, to identify the various pathogens the fish is carrying and their likely provenance. [40] Once the mutation rate of the DNA or RNA is known, it is possible to estimate how long ago a virus broke away from predecessor strains still reproducing elsewhere. Scientists are thus able to determine, for example, whether and when a particular strain of a virus diverged from another strain encountered elsewhere.

These tools also provide a means by which we can ascertain whether a fish is just carrying a virus without experiencing harmful effects or whether the fish is actually suffering from a disease the virus has caused. This discovery makes it much easier to study the physiological effects of a disease on a salmon, such as its

[39] Cohen Commission, supra., Vol. 2 at p. 113.
[40] K.M. Miller et al., "Molecular Indices of Viral Disease Development in Wild Migrating Salmon," *Conservation Physiology* 5, no. 1 (2017), doi:10.1093/conphys/cox036.

ability to tolerate warm water, evade predators and traverse rapids en route to spawning sites.

Two scientists, Dr. Dill and Dr. Miller, spoke to the Council about the risks this emerging science has identified.

Dr. Dill informed the Council that the risks of PRV and HSMI could be substantial:

- PRV is on the farms where it can and does cause HSMI;
- PRV can be transferred to wild fish;
- PRV is implicated in the heavy pre-spawning mortality of Fraser sockeye, and there are logical and biological reasons why this might be so; and
- other pathogens, including viruses, are known to be present in ONP [open net-pens] and the risk they present to wild Pacific salmon is currently unknown, but could be substantial.[41]

Although Dr. Dill explained that the science about disease transfer from fish farms to wild salmon is less certain than the science concerning sea lice transmission, the risks are very real. DFO scientist Dr. Kristi Miller's presentation clarified the science on disease transmission and highlighted some of the dangers to wild salmon.

Dr. Miller reported that the PRV-associated disease symptoms of HSMI and jaundice are present on B.C. salmon farms.42 A recent published paper by the SSHI has identified jaundice syndrome as a disease impacting a Chinook salmon farm near Tofino, and the disease is suspected to be viral-induced.43 A PRV-like virus associated with HSMI-like symptoms has also been confirmed in farmed Coho in Chile.44 There is correlational evidence that PRV is the one virus common to the farms in Tofino and in Chile, and to a finding of a similar disease outbreak in the farmed Rainbow Trout in Norway.45

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[41] Excerpt from Dr. Dill's Slide 27 in his presentation to MAACFA, with more details provided on this issue in Slides 20 through 22. In assessing Dr. Dill's credibility on the matter of assessing disease risk, it may interest the Council to know that in the face of conflicting scientific expert evidence on risks to Fraser River Sockeye from salmon farms, Justice Cohen accepted the evidence of Dr. Dill. See Cohen Commission, supra., Vol. 2 at p. 113.

[42] See the summary of Dr. K. Miller's presentation to Council in Appendix 5 of the Council's Report.

[43] See Kristina M. Miller, Oliver P. Günther, Shaorong Li, Karia H. Kaukinen, and Tobi J. Ming, "Molecular Indices of Viral Disease Development in Wild Migrating Salmon," *Conservation Physiology* 5 (2017), doi:10.1093/conphys/cox03. Especially pp. 18-20 and 29.

[44] M.G. Godoy, M.J.T. Kibenge, Y. Wang, R. Suarez, C. Leiva, F. Vallejos, and F.S.B. Kibenge, "First Description of Clinical Presentation of Piscine Orthoreovirus (PRV) Infections in Salmonid Aquaculture in Chile and Identification of a Second Genotype (Genotype II) of PRV," *Virology Journal* 13 (2016): 98.

[45] See Kristina M. Miller, Oliver P. Günther, Shaorong Li, Karia H. Kaukinen, and Tobi J. Ming, "Molecular Indices of Viral Disease Development in Wild Migrating Salmon," *Conservation Physiology* 5 (2017), doi:10.1093/conphys/cox03, especially pp. 18-20 and 29.

Japanese researchers have also found a cause and effect relationship between PRV-2 and a disease they call erythrocytic inclusion body syndrome (EIBS), which is highly similar to the jaundice/anemia and HSMI diseases described in B.C. Chinook salmon, Chilean Coho and Norwegian Rainbow Trout.46 This disease contains all of the hallmarks of these other diseases described in association with various strains of PRV in Pacific salmon around the world. It is important to note that there is only a single strain, and genogroup, of PRV in B.C., PRV-1a.47 In B.C., we observe these same disease linkages with jaundice/anemia,48 suggesting that the same strain of the virus that causes HSMI (and PRV-1a has been shown in Norway to be the cause of HSMI49) is associated with disease in Pacific salmon.

While there has not yet been research to determine the nature of the relationship between PRV and these outbreaks, certainly precaution is warranted in B.C. where we have wild Chinook salmon sharing the same water. This situation merits urgent attention given current concerns about declining Chinook abundance.

From Dr. Miller's presentation, Council learned that PRV is highly prevalent in farmed fish (~70% of farm audit samples), while PRV was detected, but not common, in migratory smolts.[50] Dr. Miller's presentation described a number of challenges associated with understanding disease impacts on wild populations and she explained that sub-lethal effects of infection in cultured fish may be more detrimental in wild fish. The spread of a lethal disease is limited by the death of the victim. Sub-lethal diseases have more opportunity to spread. Further, if a sub-lethal disease renders a wild fish more liable to predation, the result is still a premature death.

Finally, consistent with Dr. Dill's last point, we know from Dr. Miller's presentation that the SSHI has identified three novel viruses to date.[51] As this work is not yet finished, this number may well increase, and all merit more study.

Of further concern are recent scientific publications that demonstrate that PRV commonly proliferates in the red blood cells in the early stages of an infection.

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[46] Tomokazu et al., "Full-Genome Sequencing and Confirmation of the Causative Agent of Erythrocytic Inclusion Body Syndrome in Coho Salmon Identifies a New Type of Piscine Orthoreovirus," *PLOS ONE* 11, no. 10 (2016): e0165424.

[47] M.J.T. Kibenge et al., "Whole-Genome Analysis of Piscine Reovirus (PRV) Shows PRV Represents a New Genus in Family Reoviridae and Its Genome Segment S1 Sequences Group It into Two Separate Sub-Genotypes, *Virology Journal* 10 (2013): 230.

[48] See Kristina M. Miller, Oliver P. Günther, Shaorong Li, Karia H. Kaukinen, and Tobi J. Ming, "Molecular Indices of Viral Disease Development in Wild Migrating Salmon," *Conservation Physiology* 5 (2017), doi:10.1093/conphys/cox03.

[49] Ø. Wessel et al., "Infection with Purified Piscine Orthoreovirus Demonstrates a Causal Relationship with Heart and Skeletal Muscle Inflammation in Atlantic Salmon," *PLOS ONE* 12, no. 8 (2017): e0183781.

[50] See the summary of Dr. K. Miller's presentation to Council in Appendix 5 of the Council's Report.

[51] See the summary of Dr. K. Miller's presentation to Council in Appendix 5 of the Council's Report.

Red blood cells transport oxygen, and a fish whose swimming muscles are deprived of oxygen could be more likely to die from predation or fail to make it upriver to spawn. While we understand there are research projects underway to shed more light on this issue, the authors of the first publication identifying this phenomenon stated:

> PRV infection of erythrocytes [red blood cells] could have broader implications for fish health, irrespective of the presence of heart lesions.[52]

We understand that there is still more to learn about the effects of exposure to high levels of PRV on wild salmon. As Dr. Miller described in her presentation, there are a number of challenges in understanding disease impacts on wild populations, not the least of these is that we rarely see wild fish die.[53]

PRV is now very common in fish farms in many countries including Norway and Canada. As Dr. Miller presented, in B.C. farms, about 70% of farmed salmon are known to carry the virus. Industry has also acknowledged that a high number of Atlantic salmon smolts from hatcheries are infected with PRV.[54] DFO's current policy not to test for PRV means that fish farms must be transferring PRV-infected smolts into fish farms without any protective measures.

A very recent paper by Morton et al. indicates that PRV infection in wild smolts can be as high as 45% in areas where there are many salmon farms, but drops to about 5% where no salmon farms are on the migration route.[55] While the authors are very cautious to point out that the data quoted is indicative but not conclusive (due in part to the small sample size), the very high infection rate of wild salmon close to open net-pens surely highlights a need for further investigation.

Evidence suggests that the similarity of the RNA signatures of the Norwegian and B.C. forms of the PRV virus make it very likely that PRV carried by both farmed and wild salmon originated in a Norwegian salmon farm.[56]

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[52] Ø.W. Finstad, M.K. Dahle, T.H. Lindholm, I.B. Nyman, M. Løvoll, C. Wallace, C.M. Olsen, A.K. Storset, and E. Rimstad, "Piscine Orthoreovirus (PRV) Infects Atlantic Salmon Erythrocytes," *Veterinary Research* 45 (2014): 35, doi:10.1186/1297-9716-45-35. PubMed PMID: 24694042; PubMed Central PMCID: PMC4234517.

[53] For more on this topic, see Van T. La and Steven J. Cooke, "Advancing the Science and Practice of Fish Kill Investigations," *Reviews in Fisheries Science* 19 (2011): 21.

[54] Marine Harvest stated in an application to the court that five out of six of its hatcheries are infected with PRV. See *Morton v. MFO, Marine Harvest Inc and Cermaq Canada*, S. 18.1 Application for Judicial Review (2016) FC T-1710-16 ("Written Representations of the Party Applicant," January 17, 2017, paras. 4, 8, 9).

[55] A. Morton, R. Routledge, S. Hrushowy, M. Kibenge, and F. Kibenge, "The Effect of Exposure to Farmed Salmon on Piscine Orthoreovirus Infection and Fitness in Wild Pacific Salmon in British Columbia, Canada," *PLOS ONE* 12, no. 12 (2017): e0188793, https://doi.org/10.1371/journal.pone.0188793.

[56] See p. 5 of the Dill Report. See also M.J.T. Kibenge, Y. Wang, A. Morton, R. Routledge, and F.S.B. Kibenge, "Formal Comment on: Piscine Reovirus: Genomic and Molecular Phylogenetic Analysis from Farmed and Wild Salmonids Collected on the Canada/US Pacific Coast," *PLOS ONE* 12, no. 11 (2017): e188690, https://doi.org/10.1371/journal.pone.0188690.

We believe from the evidence presented to Council, and well supported by other research cited here, that we know enough about the level of risk to conclude that it is clearly sufficient to call for extreme caution.[57]

The Regulator's Response to the Science on Pathogen Transmission

Despite the science increasingly pointing to the risk posed by PRV, DFO as the regulator has chosen to refuse to take harm reduction measures that would be consistent with the body of science showing that PRV is a risk to wild salmon. As recently as January 30, 2017, DFO confirmed that it views PRV and HSMI as "not of serious concern in BC" and confirms that it is maintaining the status quo of not testing for PRV before transferring Atlantic salmon smolts into the marine environment.[58]

The conclusion that PRV and HSMI are not of serious concern in B.C. was flawed in both its reasoning and the data that reasoning relied on. DFO concluded that because DFO's Fish Health and Surveillance Program did not show elevated mortalities on fish farms, not testing for PRV did not create a risk to the protection and conservation of fish. The paper published by SSHI in February 2017 raised specific concerns about the Fish Health and Surveillance Program's methods and methodology.[59] But even if DFO's Fish Health and Surveillance Program were a paragon of regulatory efficacy, <u>the use of farmed salmon as a proxy for assessing the risk to wild salmon is logically flawed</u>: it assumes that conditions are the same for both wild and farmed salmon and fails to consider how sea lice and disease may affect those populations differently. Of critical

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[57] See for example the following that support the conclusion that the link between PRV and HSMI has been proven:

1. Palacios G. et al. "Heart and Skeletal Muscle Inflammation of Farmed Salmon Is Associated with Infection with a Novel Reovirus." *PLOS One* 5, no. 7 (2010): e11487, which concludes "as our data indicate that a causal relationship is plausible, measures must be taken to control PRV not only because it threatens domestic salmon production but also due to the potential for transmission to wild salmon populations."
2. Finstad, Ø.W. et al. "Immunohistochemical Detection of Piscine Reovirus (PRV) in Hearts of Atlantic Salmon Coincide with the Course of Heart and Skeletal Muscle Inflammation (HSMI)." *Veterinary Research* 43 (2012): 27, which concludes "Our results confirm the association between PRV and HSMI, and strengthen the hypothesis of PRV being the causative agent of HSMI."
3. Wessel, Ø. et al. "Infection with Purified Piscine Orthoreovirus Demonstrates a Causal Relationship with Heart and Skeletal Muscle Inflammation in Atlantic Salmon." *PLOS ONE* 12, no. 8 (2017): e0183781, which concludes "Purified PRV particles were inoculated into naïve Atlantic salmon. The purified virus replicated in inoculated fish, spread to naïve cohabitants, and induced histopathological changes consistent with HSMI. PRV specific staining was demonstrated in the pathological lesions. A dose-dependent response was observed; a high dose of virus gave earlier peak of the viral load and development of histopathological changes compared to a lower dose, but no difference in the severity of the disease. The experiment demonstrated that PRV can be purified from blood cells, and that PRV is the etiological agent of HSMI in Atlantic salmon."

We are not aware of any recent refereed journal articles that challenge these conclusions, but we would be very interested to learn of them.

[58] *Management Approach to PRV and HSMI for Fish Transfers in British Columbia* (2016-502-00286), as approved by Rebecca Reid, Regional Director General Pacific Region, January 30, 2017 (hereinafter "DFO Management Approach to PRV and HSMI") at p. 2.

[59] E. Di Cicco et al., "Heart and Skeletal Muscle Inflammation (HSMI) Disease Diagnosed on a British Columbia Salmon Farm through a Longitudinal Farm Study," *PLOS ONE* 12, no. 2 (2017): e0171471, doi:10.1371/journal.

importance, some species of juvenile wild salmon, such as pink and chum, passing the farms may weigh less than a gram in the early spring and thus are much more susceptible to impact.[60]

Despite our concern on this issue, DFO provided limited detailed information to Council on its management approach to PRV, and industry practices continue as though there is no cause for concern. Late last year, video shown by popular media raised concerns that bloodwater from plants processing farmed salmon may also be introducing PRV into the marine environment through processing activities.[61] This has now been confirmed: "*Ministry compliance staff conducted site visits to both the Browns Bay Packing (Campbell River) and Lions Gate Fisheries (Tofino) facilities the week of December 4, 2017. The facilities were inspected and samples collected, and lab results showed the presence of PRV*."[62]

The Regulator's Deviation from the Science on HSMI

Industry and the regulator have long held that there were no instances of HSMI in B.C. farms. Following a year-long monitoring of four B.C. fish farms under the SSHI program managed by the Pacific Salmon Foundation, it was announced that HSMI had been diagnosed in one of the four farm sites monitored.

At a subsequent meeting of the MAACFA, Dr. Gary Marty told Council that he had diagnosed HSMI as early as 2011, only "we called it something different." As Council members now know, subsequent investigation has revealed that the "B.C. definition" of HSMI differs from the "International definition" in that in addition to pathological damage in the heart and skeletal muscles of the infected fish, the B.C. definition requires that the fish display "clinical signs" or behavioural anomalies (presumably while still alive!).

We do not understand why and how the Province of B.C.'s Ministry of Agriculture and DFO, during their respective time as the responsible regulator, and the Animal Health Centre, came upon a different definition of HSMI for B.C. and why this difference was not made public from the outset. This deviation from international standards, with a complete lack of transparency, is another example of the regulator (now DFO) avoiding mainstream science to ignore potential risks and maintain the status quo.

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[60] As discussed previously, Mr. Justice Cohen recognized this risk: Cohen Commission, Vol. 3 at p. 12.

[61] See, for example: https://www.ctvnews.ca/canada/b-c-fish-processors-spewing-potentially-dangerous-bloodwater-into-key-salmon-migration-corridor-1.3696793, accessed December 22, 2017. It is interesting to note that Dr. Dill predicted this problem in his testimony to the Cohen Commission (see Cohen Commission, Vol. 2 at p. 67, with footnote to Exhibit 1540, pp. 27-29).

[62] Email from Eveline Xia, Ministerial Assistant to the Honourable George Heyman, Minister of Environment and Climate Change Strategy, to [Private Citizen], Wednesday, January 24, 2018, at 8:55 a.m., Re 313165_Blood Water testing.

Between July 2014 and January 2016, representatives from DFO, the Ministry of Agriculture and Marine Harvest Canada Inc. published three papers that all downplay the then growing scientific consensus that PRV causes HSMI.[63] Those papers find, among other things, that the presence of PRV in British Columbia predates the salmon farming industry, PRV may not cause HSMI, HSMI has not been detected in British Columbia and the British Columbia strain of PRV does not cause HSMI. None of those three papers discloses which case definition they rely on for their findings – the case definition most often relied on in scientific literature, or the case definition developed by B.C.'s Animal Health Centre. We find it troubling that the regulator is co-publishing papers with industry that are contrary to the prevailing science on PRV and HSMI. More recent scientific developments place those papers co-published by industry and regulatory authorities further outside the mainstream science on this issue. In 2017, a paper co-published by 11 experts, five of whom were DFO scientists, confirmed that fish samples they obtained in 2013 from a B.C. fish farm had been diagnosed with HSMI.[64] Another 2017 paper confirmed that PRV causes HSMI.[65]

The Regulator's Failure to Follow the Law in Regulating Pathogen Transmission

Despite DFO's acknowledgement that PRV is widely considered the leading cause of HSMI,[66] DFO's management approach does not require testing of smolts for PRV, effectively allowing for the transfer of PRV-infected smolts into open net-pens without any preventive measures to reduce the risk to wild salmon.

As discussed in more detail in the precautionary approach section below, this regulatory inaction is in direct contradiction of the 2015 Federal Court decision in *Morton v. Canada (Fisheries and Oceans)*, in which Mr. Justice Rennie found that "the weight of the expert evidence before this Court supports the view that PRV is the viral precursor to HSMI."[67] Recall that Mr. Justice Rennie's job is to listen impartially and carefully to the expert witnesses before him, and to make a decision based on the evidence.[68]

[63] G.D. Marty et al., "Piscine Reovirus in Wild and Farmed Salmonids in British Columbia, Canada," *Journal of Fish Diseases* 38 (2014). Siah et al., "Piscine Reovirus: Genomic and Molecular Phylogenetic Analysis from Farmed and Wild Salmonids Collected on the Canada/US Pacific Coast," *PLOS ONE* 11, no. 10 (2016): e0164926, http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0141475. K. Garver et al., "Piscine Orthoreovirus from Western North America Is Transmissible to Atlantic Salmon and Sockeye Salmon but Fails to Cause Heart and Skeletal Muscle Inflammation," http://journals.plos.org/plosone/article/authors?id=10.1371/journal.pone.0146229.

[64] E. Di Cicco et al., "Heart and Skeletal Muscle Inflammation (HSMI) Disease Diagnosed on a British Columbia Salmon Farm through a Longitudinal Farm Study," *PLOS ONE* 12, no. 2 (2017): e0171471, doi:10.1371/journal.

[65] Ø. Wessel et al., "Infection with Purified Piscine Orthoreovirus Demonstrates a Causal Relationship with Heart and Skeletal Muscle Inflammation in Atlantic Salmon," *PLOS ONE* 12, no. 8 (2017): e0183781.

[66] DFO's Management Approach to PRV and HSMI, supra. at p. 4.

[67] 2015 FC 575 ("*Morton v. Canada (Fisheries and Oceans)*") at para. 35.

[68] For a more fulsome discussion, see the memo: *Precautionary Measures against the Spread of PRV,* submitted to Council, October 20, 2017, providing a detailed analysis of the legal and scientific failings of DFO's *Management Approach to PRV and HSMI for Fish Transfers in British Columbia* (2016-502-00286), as approved by Rebecca Reid, Regional Director General Pacific Region, January 30, 2017.

More importantly, Mr. Justice Rennie found that not testing for PRV would be contrary to the Minister's duty under s. 56 of the *Fishery (General) Regulations* "to anticipate and prevent harm even in the absence of scientific certainty that such harm will in fact occur."[69] Contrary to this statement of the law, DFO has continued to maintain its policy of not testing for PRV.

Morton v. Canada (Fisheries and Oceans), and DFO's response to it, are important indications of DFO's approach to harm reduction. *Morton v. Canada (Fisheries and Oceans)* does not require DFO to agree with the prevailing science on pathogen transmission. However, even in the face of such scientific disagreement, *Morton v. Canada (Fisheries and Oceans)* clarifies that the law requires DFO to implement precautionary measures when the science indicates that pathogen transmission may pose a risk to wild salmon. DFO has refused to uphold this legal duty.

Despite the regulator's unwillingness to uphold its legal duties with respect to the prevention of harm and harm reduction, the Council's Report recommends a harm reduction strategy. Given the regulator's history of ignoring the science and the law, we cannot embrace or recommend such a strategy.

The Regulator's View of Acceptable Risk Thresholds

As discussed in more detail in the section on the precautionary approach below, contrary to the science and the law, DFO has adopted its own risk threshold for precautionary measures with respect to the introductions and transfers of fish. According to DFO, transfers of fish with disease should only be prohibited when there is the risk of extirpating an entire conservation unit:

> … the genetic diversity, species, or ecosystem of a stock or conservation unit may be harmed such that they cannot sustain the biodiversity and continuance of evolutionary and natural production processes.[70]

With this threshold for prohibiting transfers, DFO has indicated that in its view, the risk threshold that triggers harm reduction is set at a threat of species-level extinction. Such an approach leaves no margin for error.

Rather than interpreting the "protection and conversation of fish" as a mandate that animates all of the Minister's responsibilities, the Minister is instead interpreting it as a limit on the harm that can be caused by fish farms. In addition, the Minister's interpretation of s. 56 of the *Fishery (General) Regulations* is contrary to *Morton v. Canada (Fisheries and Oceans)*, where the Federal Court found that threshold for precautionary measures was triggered at a

[69] 2015 FC 575 at para. 99.

[70] DFO's Management Approach to PRV and HSMI, supra. at Tab 3, The Minister of Fisheries and Oceans' (Minister) Interpretation of Section 56 of the *Fishery (General) Regulations* (FGRs), para. 10.

much lower level. The precautionary principle requires that regulators "anticipate, prevent and attack the causes of environmental degradation."[71] The threshold the Minister has set is inconsistent with the proactive nature of the precautionary principle. Instead, the threshold for precautionary measures must be triggered at levels that are aimed at preventing harm to the health of wild fish, not just shy of their extirpation.

Again, we cannot recommend a harm reduction approach going forward when the regulator tasked with implementing and overseeing that approach is willing to act contrary to the prevailing science and the applicable law with respect to its duty to protect wild salmon.

Assessment of the Risk

Based on the cost and probability of harm discussed above, we do not accept Dr. Marty's conclusion to Council that: "*Salmon farm diseases pose no more than minimal risk of serious harm to migrating wild salmon populations*."[72] Justice Cohen refused to accept this position in 2012, and the research implicating the risk of disease from open net-pens to wild salmon has increased substantially since that time.

We know from evidence concerning the northern cod crisis that DFO's assessment of risk can be based on a well-established pattern of relying on partial data that have been interpreted in the most favourable light:

> The tendency to ignore uncertainty and to interpret ambiguous data optimistically affected the political bureaucracy even more severely than the scientific bureaucracy. One DFO employee explained that although decision makers did not falsify documents, "they optimized what they had. The politicians and the senior bureaucrats would run away, pick the very best numbers and come out and present them in the very best light. They would hide any negative notions, numbers, information, anything at all that took the gloss off what they had presented. Any attempt by anyone on the inside to present a different view was absolutely squashed". John Crosbie admitted to sharing this tendency towards optimism: "we have opted for the upper end of the scientific advice always striving to get the last pound of fish."[73]

We cannot accept in these circumstances that because there are scientific uncertainties or personal differences in risk assessment and tolerance for risk that it is sufficient to drift to the timid conclusion that a reasonable compromise is "harm reduction."

[71] *Morton v. Canada (Fisheries and Oceans)* at para. 41.
[72] See the summary of Dr. Marty's presentation to Council in Appendix 5 of the Council's Report.
[73] Unnatural Disaster, supra. at p. 15.

This is particularly so when it leads to the recommendation for more flexibility in siting of open net-pen farms due to climate change, rather than calling for the removal of farms from wild salmon migratory routes. In the Dill Report it is noted that salmon infected with PRV have a reduced tolerance for high temperatures,[74] which would increase the impact of climate change on wild salmon, thus increasing the risk associated with PRV.

Attempting to respond to risk by addressing simple, short-term objectives in a "harm reduction" approach suggests that the problem the aquaculture industry is facing is one of public perception and that perception can be managed by easy, short-term solutions that avoid significant regulatory reform. This approach mistakes cause for effect. Lack of public trust is not the cause of the aquaculture industry's problems. Lack of public trust is what we get when the regulator fails to adequately manage risk. By advocating for short-term objectives to sway public perception, the Council's Report is protecting the failing status quo at the expense of wild salmon.

Given the level of risk, we believe the only way to build trust is through reform of the regulation of the industry. That reform begins with the regulator following the science and the law and by ceasing to issue licences to introduce and transfer PRV-infected smolts into open net-pens until it can be shown that wild Pacific salmon are not impacted. This puts the burden of proof squarely where it should be – on the regulator and the industry. That reform continues by acknowledging that the inherent risks imposed by fish farms cannot be adequately mitigated with open net-pens and follows that acknowledgement through to its logical conclusion by embracing a transition to land-based closed containment.

We do not accept any assertion that because there are other stressors impacting wild salmon that are much more difficult to control (such as climate change) we should give up on controlling the stressors that are within our control. This is particularly true given that the Council on the Status of Endangered Wildlife recently recommended that species of Fraser River sockeye salmon be listed under the federal *Species at Risk Act*, thus underscoring the fragile state of some populations of wild salmon.[75]

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[74] Dill Report, supra. at p. 5.

[75] See, for example, the article by Ivan Semeniuk in the *Globe and Mail* (B.C. Edition), December 5, 2017, p. A5. In the article he reported that during a marathon session in Ottawa, scientists voted that eight of the 24 populations of Fraser River sockeye should be listed as endangered – representing the highest level of risk that the population could someday be lost. The Council determined that two other populations should be listed as threatened and five more designated "of special concern." The Council also voted that the remaining nine populations of sockeye still occur in large enough numbers on the Fraser that they do not warrant listing. See https://www.theglobeandmail.com/news/national/what-these-species-say-about-the-worrisome-state-of-canadas-wildlife/article37193496/.

Rather, we accept:

- the research, including Dr. Rosenau's analysis, showing there is very good evidence that salmon passing close to open net-pens have substantially worse survival rates than those that do not;
- Dr. Dill's conclusion that risks to wild salmon from sea lice produced in open net-pens are "unambiguous and substantial"; and
- that while we do not yet have a complete picture of the effects of high levels of exposure to PRV on wild salmon, the available evidence presented by researchers such as Dr. Kristi Miller strongly supports a conclusion that the level of risk is high.

Overall, we conclude from the work of the Council, that the risk of harm is sufficiently high to call for extreme caution, and to require reform of the industry to be sustainable in B.C.

The Precautionary Approach

In hindsight, there is no question that failing to exercise sufficient caution in managing the northern cod stocks contributed to the collapse of the cod fishery. If we heed the lessons that were learned on the east coast, we will proceed with caution, rather than express regret for not having done so:

> By July [1992], CAFSAC [Canadian Atlantic Fisheries Scientific Advisory Council] estimated that the northern cod stock had fallen to between 48,000 and 108,000 tonnes. Only then did Crosbie impose a moratorium on fishing for northern cod. Was he too late? Crosbie has considered that question: "I wish I could say that we weren't too late in closing the fishery. I wish I could say the northern cod and other species are recovering and that the seas off Newfoundland will once again teem with fish as they did for the first five hundred years of our history. I wish I could say it, but I can't. Not yet. Probably never."[76]

The only good that can come of our failures is to learn from them. Our goal is to make sure we are not too late; that we don't have to say "probably never" when the generations that follow ask us about the recovery of wild Pacific salmon runs like Fraser River sockeye. Rather, our goal must be to be better, and to make the admittedly harder choice between short-term economic gain and longer-term ecological protection. We must listen to what science is telling us, making the choice to do all that we can to remove threats to wild Pacific salmon, including those posed by open net-pen fish farming. This is particularly so as climate change and future environments are expected to compound these risks and further complicate the management of open net-pens.

[76] Unnatural Disaster, supra. at p. 20.

Science should be the ultimate arbiter of suppositions regarding actual and potential interactions between wild and farmed salmon; and where there is a risk of serious environmental damage, the law is clear: decision makers are obligated to take a precautionary approach to protect wild salmon, and they cannot use scientific uncertainty to excuse regulatory inaction. We need to stand firm on this. The precautionary principle is not optional; it is the law of our land.[77]

In 2012, Mr. Justice Cohen wrote:

> … DFO suffers from conflicting institutional mandates – on the one hand to regulate salmon farms for the conservation of wild salmon, and on the other hand to promote salmon farm development and products. The testimony of the deputy minister to the effect that the minister of fisheries and oceans is not well placed to enforce section 36 of the Fisheries Act against salmon farms because of a conflict is telling and, in my view, is equally apparent in relation to section 35 … DFO faces conflicting roles in having to tell the world that Canada's farmed salmon products do not threaten the sustainability of wild salmon, yet at the same time credibly examining the possibility that such products are not safe. DFO's regulatory work – to site farms, to set conditions restricting farm growth, and to monitor farms and take enforcement actions against them – all suffer from this institutional conflict.[78]

He went on to conclude:

> As long as DFO has a mandate to promote salmon farming, there is a risk that DFO will act in a manner that favours the interests of the salmon-farming industry over the health of wild fish stocks.[79]

He identified the following risks of DFO's conflicting mandates to conserve wild stocks and to promote the salmon farming industry:

- There is a risk that DFO will not proactively examine potential threats to migrating sockeye salmon from salmon farms, leaving it up to other concerned parties to establish that there is a threat.
- There is a risk that DFO will impose less onerous fish health standards on salmon farms than it would if its only interest were the protection of wild fish. Farmed salmon may tolerate certain diseases or pathogens differently from wild salmon, such that the farmed fish would not

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[77] See Appendix 9 of the Council's Report for a full discussion on the legal obligation for the Federal Minister to take a precautionary approach. See also *Morton v. Canada (Fisheries and Oceans)* at paras. 96-99 where Mr. Justice Rennie found that DFO was not applying the precautionary principle as required by law and had unlawfully sub-delegated discretionary decisions to industry with respect to precautionary measures. Canada's Policy for the Conservation of Wild Pacific Salmon provides a useful framework for determining acceptable risks.

[78] Cohen Commission, supra., Vol. 1, *The Sockeye Fishery,* at p. 418.

[79] Cohen Commission, supra. at p.12.

necessarily require treatment except for their potential to spread disease or pathogens to wild fish ...

- There is a risk that DFO will be less rigorous in enforcing the Fisheries Act against the operators of salmon farms.[80]

We see these risks playing out, manifestly in DFO's capture by industry and abandonment of the precautionary principle.

As discussed above, without explanation as to why, DFO's Fish Health and Surveillance Program has departed from the International Standard for diagnosing HSMI in farmed Atlantic salmon. By adding the requirement for "clinical signs" for a diagnosis of HSMI, DFO has adopted a diagnostic model that, by definition, will result in fewer diagnoses of HSMI. To the best of our knowledge, DFO's Fish Health and Surveillance Program has never diagnosed HSMI. This adoption of a model that under-diagnoses HSMI does not adhere to the precautionary principle. Moreover, while DFO's Fish Health and Surveillance Program has for many years said that the heart lesions it has observed were not HSMI, and instead recorded those lesions as cardiomyopathy of an unknown cause, it does not appear that DFO has investigated what may be causing the lesions it observed.

In *Morton v. Canada (Fisheries and Oceans)*, the court found that s. 56 of the *Fishery (General) Regulations* requires DFO to apply the precautionary principle with respect to HSMI and PRV, and that fish farm licence conditions were incompatible with governing legislation and regulations that embodied the precautionary principle, saying:

> ... [t]he respondents' [Marine Harvest and DFO's] arguments with respect to the precautionary principle are inconsistent, contradictory and, in any event, fail in light of the evidence.[81]

Justice Rennie also found that DFO's position on the relationship between PRV and HSMI were not aligned with the weight of scientific evidence.[82] Effectively, DFO was advancing positions favouring industry when those positions are contrary to what is accepted by the scientific community.

In October 2017, Council was provided with a detailed analysis of the legal and scientific failings of DFO's *Management Approach to PRV and HSMI for Fish Transfers in British Columbia,* approved in January 2017.[83] Despite DFO's acknowledgement that "PRV is widely considered the leading cause of HSMI,"[84] DFO's approved management approach is to allow for the transfer of smolts to open net-pens without even testing for PRV, relying on an interpretation of s. 56

[80] Cohen Commission, supra. at p. 12.
[81] *Morton v. Canada (Fisheries and Oceans)* at para. 35.
[82] *Morton v. Canada (Fisheries and Oceans)* at para. 44.
[83] DFO's Management Approach to PRV and HSMI, supra.
[84] DFO's Management Approach to PRV and HSMI, supra. at p. 4.

that is expressly contrary to the court's decision in *Morton v. Canada (Fisheries and Oceans)*.

Simply put, DFO's response in the face of a decision by a Federal Court judge requiring it to apply the precautionary principle is to ignore the science and abandon the rule of law. With respect to the regulation of aquaculture in B.C., it appears that DFO has abandoned its constitutional mandate to protect fisheries and oceans and the fundamental principles of the Canadian legal tradition in order to serve industry's interests.

The precautionary principle requires government to anticipate and attack threats of environmental degradation and irreversible damage. The Council on the Status of Endangered Wildlife's recent recommendation that species of Fraser River sockeye salmon be listed under the federal *Species at Risk Act* underscores the fragility of wild salmon, and makes it almost impossible for any government official to argue that populations of wild salmon do not face the imminent risk of irreversible damage.[85]

A court reviewing a government official's decision with respect to the implementation of precautionary measures to protect wild salmon is likely to consider if the precautionary measures implemented are reasonably proportionate to the nature of the environmental damage they were aimed at preventing. Given the mounting evidence of the imminent threat to the long-term viability of wild salmon populations, it is increasingly likely that a court looking for a proportionate response to a threat of irreversible damage could find that significant, and perhaps drastic, precautionary measures are required.

The Minister of Fisheries and Oceans has interpreted s. 56 of the *Fishery (General) Regulations* as prohibiting introductions or transfers of fish that could threaten the viability of conservation units of wild salmon. While we do not agree with the Minister of Fisheries and Ocean's interpretation that s. 56 requires population-level effects, even if DFO's interpretation is correct, then the Council on the Status of Endangered Wildlife's recommendation to list species of Fraser River sockeye salmon must surely trigger protective measures and require the prohibition of introductions or transfers that could be harmful to those populations the Council on the Status of Endangered Wildlife has recommended be listed.

A Provincial Minister's Duty to Apply the Precautionary Principle

In the absence of DFO's willingness to apply the precautionary principle, we must look to the Province. Under s. 11 of British Columbia's *Land Act,* the Minister can only dispose of Crown land if the Minister considers it advisable in the public interest.

[85] See, for example, the article by Ivan Semeniuk in the *Globe and Mail* (B.C. Edition), December 5, 2017, p. A5.

The precautionary principle has evolved into a norm of international law and is quickly becoming a norm within Canada's common law. The courts are increasingly interpreting statutes as embodying the precautionary principle even if those statutes do not expressly invoke the precautionary principle by name or adopt the language normally associated with its expression. The Supreme Court of Canada did this both in *114957 Canada Ltée (Spraytech, Société d'arrosage) v. Hudson (Town),* 2001 SCC 40, and in *Castonguay Blasting Ltd. v. Ontario (Environment),* 2013 SCC 52. In *Spraytech,* the Supreme Court found that municipal bylaws embodied the precautionary principle; in *Castonguay Blasting,* it held that provisions of Ontario's *Environmental Protection Act* embodied the precautionary principle. The Federal Court reached a similar result in *Morton v. Canada (Fisheries and Oceans),* 2015 FC 575, with respect to regulations under the *Fisheries Act.*

Based on this growing trend in the case law, it is increasingly likely that, where environmental issues may be involved, and a Minister is required to act in the public interest, a court could find that statutory provisions governing that minister's conduct engage or embody the precautionary principle.

Under s. 11 of British Columbia's *Land Act,* the Minister can only dispose of Crown land if the Minister considers it advisable in the public interest. Given the very significant environmental issues that must be considered when granting licences of occupation for finfish aquaculture, a court could very well find that the precautionary principle is engaged and the Minister must consider if granting tenures for finfish aquaculture is consistent with the precautionary principle's requirement to anticipate and attack potential environmental degradation or irreversible damage.

Thus, in our opinion, a timid recommendation for harm reduction does not go far enough to meet the legal duty to apply the precautionary principle which prohibits regulatory inaction when there is a threat of environmental degradation.

The Constitutional Obligation to First Nations

Simply stated, Canada's Constitution requires both the federal and the provincial governments to respect the rights of First Nations. A significant number of First Nations with open net-pen farms operating in their traditional territories, as well as First Nations that rely on wild salmon that must migrate near open net-pens, oppose open net-pen fish farms.[86] The occupation of salmon farm facilities in

[86] On September 12, 2017, the First Nations Fisheries Council of British Columbia issued a press release stating opposition to open net-pen fish farms:

> The First Nations Fisheries Council of British Columbia (FNFC) passed a resolution at their last Executive meeting expressing that the production of Atlantic salmon in open net pens along the Pacific coast poses too great a risk to wild salmon populations. While the FNFC recognizes that a small number of First Nation communities rely on agreements with fish farm operators for economic opportunity, the FNFC has heard from the vast majority of nations that fish farms cannot be supported.

‘Namgis and Musgamagw territories speaks to their level of concern. Going ahead without the consent and in the face of direct opposition from impacted First Nations, regardless of the consent of other First Nations, would violate the United Nations Declaration on the Rights of Indigenous Peoples and Canada’s Constitution:

> While some First Nations have entered into agreements with salmon farming corporations, wild salmon originating from distant regions are passing through these salmon farm clusters and so impact is borne by First Nations who have not been consulted. As well, salmon farms exist in territories where they were never given permission to operate, were served with eviction notices, and drew strong opposition by First Nations and others to site expansions. There are First Nations who are suffering substantive losses as a result of recent sea louse outbreaks, with no compensation or relief in sight.[87]

Accordingly, we fully support the Council’s recommendation to:

> Acknowledge and incorporate First Nations’ rights, title and stewardship responsibilities in all aspects of fish farm governance, including tenuring, licensing, management and monitoring in a manner consistent with the United Nations Declaration of Rights of Indigenous Peoples (UNDRIP).

Further, both governments must act in accordance with constitutionally protected Aboriginal rights under section 35 of the Constitution.

In *Tsilhqot’in Nation v. British Columbia*, 2014 SCC 44, the Supreme Court of Canada found that the authorization for activities undertaken without the consent of First Nations who later establish Aboriginal title could be cancelled after Aboriginal title is proven and that the Crown must take steps to preserve Aboriginal interests pending proof of Aboriginal title.[88] Many First Nations have made it clear that they do not consent to fish farms in their territories. Few, if any, of those First Nations have ceded, released or surrendered their claim to Aboriginal title and may in the future prove Aboriginal title.

Additionally, a Minister when exercising discretion must consider how his or her decision will advance or impair reconciliation. Much like the precautionary principle limits the range of decisions a Minister can make to those that

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The full press release is available at http://www.fnfisheriescouncil.ca/wp-content/uploads/2015/09/FNFC-Press-release-non-support-open-net-pens-sep-2017.pdf, accessed January 12, 2018.

[87] First Nations Wild Salmon Alliance, *Wild Salmon Strategy Session: The Future of Wild Salmon – Removing Barriers to Informed Decision-Making*, Report on Proceedings and Recommendations, April 18-19, 2016, at p. 20. Available at http://fnwildsalmon.com/wp-content/uploads/2016/05/WSA_Final_Report_v4-05.19-WEB.pdf, as of January 3, 2018.

[88] *Tsilhqot’in Nation v. British Columbia*, 2014 SCC 44, at paras. 91 and 92.

reasonably exercise precaution in the face of environmental risk, s. 35 of the *Constitution Act, 1982* limits Ministers to decisions that reasonably advance reconciliation.[89] Given the vociferous objections to fish farms by some First Nations, it is difficult to see how renewing licences in the territories of those First Nations could advance reconciliation.

We believe this is an important opportunity for the Minister, based on environmental and Indigenous concerns, to be the first in a very long time to align B.C. with the established and emerging trends in both environmental and Indigenous law.

Where We Should Be

> Canada's fisheries managers tried desperately to blame the groundfish collapse on forces beyond their control. Colder water temperatures, they suggested, had driven the cod away, while increasing seal populations had eaten both cod and capelin, cod's favourite food. It has become increasingly clear, however, that such environmental factors played only minor roles in the destruction of the stocks. The real problem, scientists now widely agree, was that the politicians and bureaucrats running Canada's Atlantic fisheries permitted nay, encouraged overfishing.[90]

<u>We must not allow regulators to take the disastrous path of blaming environmental factors for their failure to manage the risks associated with open net-pen aquaculture</u>. For all of the reasons outline above – the ecological and cultural importance of wild salmon, the economic value of the wild salmon economy, the risks posed by sea lice and pathogens, the legal duty to apply the precautionary principle, and the legal and moral obligation to First Nations – we believe that an approach that emphasizes "harm reduction" is simply not sufficient.

Mr. Justice Cohen was certain (and so are we) that most British Columbians, if allowed the opportunity to wade into the discussion on acceptable level of risk, would support nothing greater than minimal risk to wild salmon. We are convinced the weight of the science tells us we are well beyond "minimal risk." Justice Cohen did not define minimal risk. We contend this is because he understood that British Columbians should be the ones to make that decision. We should embrace public input and discussion, not supplant it with the industry's view of acceptable risk.

We all agree that given the importance of wild salmon to First Nations, to whom we owe a special duty, and to all British Columbians, this debate cannot boil

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[89] *Kainaiwa/Blood Tribe v Alberta (Energy),* 2017 ABQB 107, at paras. 129 and 130.
[89] Unnatural Disaster, supra., at p. 4.
[90] Unnatural Disaster, supra., at p. 4.

down to simple economics. Even if we did base our decision on pure economics, the risk of damaging the wild salmon economy is not worth taking.

The responsible course of action, in our opinion, is to support the evolution of the industry and the development of alternative salmon farming technologies. As discussed above, optimization, standardization and scale are starting to impact the economics, investor interest and commercial-scale adoption of closed containment salmon farms. B.C. has an important choice to make – do we want to be a leader in the new technology which is destined to replace open net-pen salmon farming, or do we want to cede the ground to Norway (again) and others more venturesome than ourselves, while putting our wild salmon and the economy that goes with it at risk?

If a program to transition open net-pens to closed containment systems comes into being, it would be highly desirable to have the salmon farm companies work with government to help effect a smooth transition. Norway is a highly respected country in the view of most Canadians. It is likely that the Norwegian companies that control the majority of the open net-pen salmon farms in B.C. will want to continue to build a stable business relationship based on sustainable production methods with the governments and people of British Columbia. However, it may also happen, that some, or perhaps all, of the existing salmon farm companies elect to close their operations in B.C. and move production elsewhere. If this happens, it would be disappointing, but this prospect should in no way slow the transition out of open net-pen farms to closed containment facilities, nor discourage Canadian operators from participating in this emerging opportunity. Our wild B.C. salmon are too important culturally, ecologically and financially to risk their further decline.

To help preserve jobs to the greatest extent possible, planning for the transition should start immediately. More work may be needed to determine the best types of closed containment facility to use, to determine how quickly to effect a transition and to determine interim measures for a transition out of open net-pens. All actions must proceed in a manner that minimizes the risk of serious additional harm to wild salmon; we have the opportunity to choose a better path now and we should not squander it.

Where to Now? – The Recommendations

> *"Cheshire Puss…Would you tell me, please, which way I ought to walk from here?"*
> *"That depends a good deal on where you want to get to," said the Cat.*
> *"I don't much care where–" said Alice.*
> *"Then it doesn't matter which way you walk," said the Cat.*
> *"–so long as I get SOMEWHERE," Alice added as an explanation.*
> *"Oh, you're sure to do that," said the Cat, "if you only walk long enough."*

Alice's Adventures in Wonderland (Chapter VI)

Unlike Alice, we believe that most British Columbians know where we want to go:

1. Protect and restore wild Pacific salmon.

2. Grow B.C.'s salmon farming industry and help it evolve into a clean, green, sustainable closed containment industry we can be proud of.

3. Reconcile with First Nations.

To get there we need to chart our path. We can get to where we want to go if we do the following:

1. Acknowledge that British Columbians have a very low tolerance for putting wild salmon at risk, and accept that the science on impacts such as sea lice and pathogen transmission, combined with statistical data which strongly suggests that salmon which pass by open net-pen farms fare substantially worse than those which do not, confirms that open net-pen farms pose more than a minimal risk of serious harm to wild salmon and to the environment.

2. Urge Premier Horgan and his Cabinet to announce that the Province will not renew existing tenures and will not issue new tenures for marine finfish salmon farms using open net-pens on the basis that they are not socially and ecologically sustainable.

3. Call on the Federal Government to increase oversight and public transparency in compliance with conditions of licences and the management of existing farms in the interim, including a prohibition on the transfer of PRV-infected smolts to open net-pens.

4. Commit to the development and implementation of a plan to transition (and sustainably grow) British Columbia's aquaculture industry to closed containment by a set date (i.e. 2025).

5. Recognize the future risks from climate change and other environmental factors outside of our immediate control, and commit to investing in habitat restoration to further protect B.C.'s wild Pacific salmon and support sustainable, healthy, genetically diverse wild salmon populations that are more resilient to these risks.

All of which is respectfully submitted by Council member Tony Allard.

Attachments to Appendix 9:

1. *The Risks of Open Net Pen Salmon Farms to Wild Pacific Salmon: Summary of Scientific Findings*, a report prepared for Wild Salmon

Forever by Lawrence M. Dill, PhD FRSC, Professor Emeritus, Simon Fraser University, November 8, 2017.

2. Excerpt from Pacific Salmon Commission Report: Economic Impacts of Pacific Salmon Fisheries, July 2017.

3. Timeline for PRV Fish Health Impairment Potential, prepared by Dr. R.D. Routledge, Professor Emeritus, Simon Fraser University.

Attachment 1:

The Risks of Open Net Pen Salmon Farms to Wild Pacific Salmon: Summary of Scientific Findings

A report prepared for Wild Salmon Forever by Lawrence M. Dill, PhD FRSC, Professor Emeritus, Simon Fraser University

November 8, 2017

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About the Author

Lawrence Dill obtained his PhD from UBC in 1972, returning to university after having spent 2 years as a DFO salmon biologist. He joined the Department of Biological Sciences at SFU in 1974 and rose through the ranks to become a University Research Professor. He was elected as a Fellow of The Royal Society of Canada in 1997 and was awarded the 2004 IgNoble Prize in Zoology for his landmark study of herring flatulence. Currently he is a Professor

Emeritus at SFU and continues to supervise graduate students. During his career he has published nearly 170 scientific papers in refereed journals. In recent years much of his research and that of his students has been on the interactions between sea lice and wild salmon. He produced a research report for the Cohen Commission on the impacts of salmon farms on Fraser River sockeye salmon, and co-authored the WWF Salmon Aquaculture Dialogue report on sea lice. Never happy far from the water, he lives in a floating home in Victoria, BC with his wife Elizabeth and Digby, his Nova Scotia duck toller.

Executive Summary

Concern about the potentially harmful interactions between wild Pacific salmon and farmed salmon contained in open net pens has been a longstanding issue in British Columbia and elsewhere. Here I review recent scientific findings relevant to this debate.

My principal findings are as follows:

1. Because of the large numbers of farmed Atlantic salmon in close proximity in open net pens (ONPs), lice, viral and other pathogen populations can grow to very large sizes, shedding millions of infective stages (lice) or copies into the local environment outside the farm, where they can infect wild fish. In addition, conditions inside the farms are exactly those which evolutionary theory predicts will lead to selection for increased pathogen virulence, i.e., an increased negative effect on its host, and there is evidence that this has happened in aquaculture facilities. Therefore, what comes out of ONPs can be much more dangerous to wild salmon than the pathogens that the wild salmon may have passed to the farmed Atlantic salmon in the first place.

2. The risk to wild salmon from sea lice produced in Open Net Pens (ONPs) is unambiguous and substantial. Lice have been shown to reduce productivity of both wild pink and coho salmon

populations in the Broughton Archipelago, and there is no reason to think they are not having similar effects elsewhere on the BC coast. The mechanisms by which lice impact individual survival are well understood, and these individual and population level effects have been found consistently throughout the world and are supported by large-scale experiments.

3. Piscine orthoreovirus (PRV) and the disease it causes (Heart and Skeletal Muscle Inflammation or HSMI) have recently been confirmed on a BC salmon farm. The virus has been implicated in the heavy pre-spawning mortality of Fraser River sockeye salmon. Additionally, it has been shown that productivity of these stocks depends in part on the number of Atlantic salmon in the ONPs that the smolts pass on their northward migration to the open ocean. While we do not know what it is about the farms that underlies this latter relationship, pathogen transmission remains the most likely explanation. It is tempting to speculate that PRV may be involved but we don't yet know the source of the PRV with certainty.

4. A number of other viruses and disease-causing organisms (bacteria, myxozoans and microsporideans) are known to be present in ONPs The risk they present to wild Pacific salmon is currently unknown, but could be substantial. There is evidence that some can be passed to wild salmon with harmful effect, but we cannot say with certainty that any wild salmon population has declined because of them.

5. Lice (and to an extent, viruses) have been shown to affect the vulnerability of wild salmon to other mortality agents, including starvation and predation. Even if these pathogens do not kill the fish directly, infected fish are likely to be rapidly removed from the population by a predator, making the business of proving that

a given agent causes widespread wild salmon mortality and population decline a very difficult task.

6. As a result of these indirect effects, the impact of parasites and viruses on wild salmon depends on environmental factors such as water temperature and competition with other species. The less benign the environment, the greater the impact to be expected.

7. Apparently healthy fish in the ONPs may still be fighting infection and releasing viral particles into the waters surrounding the farm, where they can infect wild fish. Therefore the fact that only a small percentage of farmed salmon die of a given disease greatly underestimates the risk they present to wild salmon.

8. Lice impacts on wild salmon can be mitigated by appropriate control strategies on the farms, particularly the timing of parasiticide treatment. Although there is concern that lice may evolve resistance to SLICE and other chemicals used to control them, a large wild fish population may help to maintain the efficacy of SLICE and delay the evolution of resistance, meaning that the preservation of healthy wild salmon populations is in the salmon farmers' self interest.

9. The evidence of risk to wild salmon is sufficient that the precautionary principle should be invoked, and Governments should mandate and support the aquaculture industry's move from ONPs to land-based closed containment production systems.

Introduction

Most farmed salmon in BC are grown to market size in open net pens. At any one time there are approximately 80 active farms in BC (out of 119 tenures), each consisting of a number of separate net pens, containing up to 3⁄4 of a million fish in total. Roughly 95% percent of the fish raised in BC are non-native Atlantic salmon (*Salmo salar*); a small minority of farms, all in Clayoquot Sound, contain endemic chinook salmon. The farms are distributed widely along the coast, mostly south of Port Hardy in the Inside Passage as well as along the west coast of Vancouver Island. This places them along the migratory routes of wild juvenile salmon heading to the open ocean as well as of the adult fish returning to their natal streams to spawn.

Since the Cohen Commission of Enquiry (2011) and its associated scientific reports, there has been a considerable amount of new research published on the risks that open net pen salmon farms (hereafter ONPs) may pose to wild Pacific salmon, especially the juveniles. The present report is an attempt to update and summarize our scientific understanding of these risks. Because I believe that research findings do not become accepted knowledge until published in the peer reviewed scientific literature, I will base this report only on such sources, and not on grey literature, unpublished research, anecdotes or opinion. Although the focus will be on research conducted on the interactions between farmed Atlantic salmon and wild Pacific salmon (*Oncorhynchus* species) here in BC, research conducted in Europe will be referred to where appropriate. To avoid long lists of citations I will refer to synthesis or review articles wherever possible. I will also indicate some areas where more research is warranted.

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The risk of ONP's comes entirely from the fact that they are "open" and form a single interacting system with the surrounding waters and their wild salmon inhabitants. As a result, anything infecting the salmon outside the pens can be transmitted to the fish inside, and vice versa. Both parts of this two way street are important, but we are concerned here with risks to wild salmon coming from inside the farms. Parasites and diseases, albeit sometimes introduced by wild fish, change in abundance and perhaps virulence in the ONP environment and can then be transferred back to the wild populations, sometimes at earlier and more vulnerable life stages. The likelihood of this occurring is likely to be increased by wild juveniles being attracted to the ONPs by excess food and

nighttime lighting. Unlike Las Vegas, what happens in net pens doesn't stay in net pens.

As implied above, parasites (lice) and diseases are the main potential threats to wild fish from salmon farms and will be the main focus of this report. I will deal with each separately before more briefly considering some other possible risks to wild salmon posed by ONPs.

Lice

There are two species of ectoparasitic lice commonly found in relatively large numbers on the Atlantic salmon in the farms: *Lepeophtheirus salmonis*, the salmon louse (hereafter Leps), and *Caligus clemensi*, the sea louse. Both are generally referred to as sea lice. A main difference between these two, apart from the fact that Leps is much larger, has to do with their host specificity: Leps is only able to complete its life cycle and produce eggs on salmonids, while *Caligus* is a host generalist and is commonly seen on herring (e.g. 60) and other species of fish. This has some important implications discussed below. Most of the research on lice has been conducted on Leps; little is known about the impacts of *Caligus* on their hosts. Despite the fact that *Caligus* is sometimes more abundant on farmed Atlantic salmon than is Leps, Government regulations mandating treatments at certain threshold louse infection levels deal only with the latter species.

Genetic analysis (85) has suggested that Leps from Europe and BC are not identical, but there is no indication that this is anything other than random variation, perhaps due to genetic drift, or that the two types are functionally distinct. In other words there is no reason to believe that the results from host-impact studies in Europe, where lice have been a huge problem for wild salmon and trout, are not just as applicable here in BC.

Despite earlier arguments in the scientific literature it is now undisputed that ONPs are the primary source of heavy Leps infestations on wild juvenile salmon, including on pink and chum salmon in the Broughton Archipelago where most of the BC field work has been conducted (45, 60, 33, 51) as well as on sea trout and salmon in Europe (76, 70). In addition, there is evidence that pink and chum salmon and Fraser River sockeye smolts pick up both Leps and *Caligus* as they pass ONPs on their way north through the Discovery Islands (68, 69). The only remaining contentious issue is what impact this has on wild salmon populations; the evidence, to be discussed below, suggests it may be considerable.

3

Viruses

Sea lice are relatively large and obvious, easily observed and counted, and can even be cultured in the laboratory. This is one reason that they have been extensively studied. Most other salmon pathogens are invisible to the naked eye, and so have largely flown under the radar. However, recently, and aided by new molecular methods, much more attention has been paid to understanding the potential risk that viruses and microparasites pose to wild fish in BC and elsewhere.

Piscine orthoreovirus: Among the viruses, much of the current concern has focused on Piscine orthoreovirus (PRV). It has long been suspected (e.g., 65, 17) to cause a disease known as Heart and Skeletal Muscle Inflammation (HSMI), and this has very recently been confirmed experimentally (83). One reason it has taken so long to identify PRV as the causative agent of HSMI is that the virus can be present without causing any obvious signs of disease (84, 23). Another has to do with disagreement over whether clinical behavioural indicators of disease must be present before HSMI can be diagnosed. The virus first appears in the fish's red blood cells where it replicates before spreading to other organs and causing the lesions associated with HSMI (18).

PRV is ubiquitous in farmed Atlantic salmon in Norway and has been shown to transfer to wild Atlantics there (22) and PRV or PRV-like viruses (there may be a diversity of "species") have been found in coho salmon in both Chile (24) and Japan (74) and in hatchery rainbow trout in Norway (64). PRV has also been isolated from wild cutthroat trout, and from steelhead, coho, chinook and chum salmon in BC (38, 71). It can be passed from fish to fish by cohabitation (41).

HSMI has been found on at least one open net salmon farm in BC (14; see also 38, 71). The presence of some sort of virus in ocean caught adult Fraser sockeye is a predictor of very low survival to spawning (they have a 13.5-fold greater chance of dying en route; 55), and PRV is one of the pathogens that seem to correlate with pre-spawn mortality (56). The latter study (56) was the first record of PRV in sockeye salmon, and it was subsequently reported in sockeye smolts (25). While it is tempting to suggest these fish picked up the virus when passing salmon farms, either as smolts or adults, there is no evidence to confirm or refute this hypothesis at this time. However, the PRV found in BC is genetically very similar to Norwegian strains, and may have diverged from it as recently as 2007 (38), suggestive of farm origin, at least initially.

There are good reasons why PRV may compromise a fish's ability to complete the arduous migration to the spawning grounds. The high proportion of red blood cells infected in the early stages of HSMI is likely to reduce their oxygen carrying capacity and result in anemia and poor swimming performance; the subsequent lesions in heart and muscle tissue undoubtedly also make the salmon less likely to complete their migration successfully. Finally, Atlantic salmon infected with PRV have reduced tolerance for high temperatures (48). Should this be true for Fraser sockeye salmon, it could also help to explain why PRV seems to be associated with low survival, given the unusually high temperatures in the river in recent years.

The findings that many (perhaps even a majority) of apparently healthy farmed fish may be infected with PRV and in a disease state, i.e., actively mounting a cellular defense to the virus (14), have exceedingly important implications. If this is generally true then these fish are most likely shedding millions of viral particles in their faeces, or through their gills and skin, into the ONPs and the water surrounding them, potentially putting wild fish at risk. Therefore the fact that only a small percentage of farmed salmon die of a given disease greatly underestimates the risk they present to wild salmon.

Other viruses: Concerns have been raised that three other viruses may pose a risk to wild salmon: infectious salmon anemia virus (ISAV), infectious haematopoietic necrosis virus (IHNV), and salmon leukemia virus (SLV). A recent paper on risks of ONPs (58) summarizes the available information on each of these viruses and concludes that all of them (as well as PRV) pose " a greater than minimal risk of serious harm" to wild salmon in BC. SLV and IHN have certainly been responsible for disease outbreaks in BC farms, and (57) determined that a small percentage of wild migrating sockeye had IHNV, using a powerful new molecular technique able to detect an active viral disease state in fish that otherwise appear healthy. The evidence for ISA in BC is controversial but there is published evidence of a variant form of ISA being in both farmed Atlantic and wild Pacific salmon (39).

Another virus beginning to raise concern is ENV – erythrocytic necrosis virus, which is known to cause severe physiological disruption in chum salmon fry (49.). Herring is a major host for this virus (16, 28), which suggests the possibility that it could be introduced to ONPs by herring attracted there by feeding opportunities. Indeed, ENV has been found in farmed Atlantic salmon (57). The involvement of herring in the host- parasite dynamics, as is also the case with *Caligus* (see above), leads to the possibility of some deleterious food chain effects for wild salmon, i.e., reduced food availability.

Other Pathogens

In addition to sea lice and viruses, a number of other pathogens found in farmed fish may pose a risk to wild salmon.

Bacteria: Two bacterial diseases have the potential to impact wild salmon. The first, bacterial kidney disease (BKD) is caused by *Renibacterium salmoninarum*. It is relatively uncommon in Atlantic salmon in net pens (37) but very pathogenic to sockeye. The second, *Piscirickettsia salmonis* is a significant pathogen of fish in net pens, including Atlantics, chinook and coho, but has not been found in wild salmon to date (37).

Myxozoans: These tiny parasites, distantly related to jellyfish, have a two-host lifecycle involving an invertebrate. One species, *Parvicapsula minibicornis*, is found in both smolts and adults of sockeye salmon and heavy infection impedes the fish's ability to recover from exercise (81) and can cause mortality (37). It is considered to be of "high risk" to Fraser River sockeye (37).

Microsporideans: This is another group of microparasites, related to fungi. One species, *Loma salmonae*, a well-known aquaculture pathogen (37), reduces the probability of sockeye surviving to spawning (56).

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While all of these other pathogens can on occasion be found in ONPs, and can pose a threat to wild salmon, there are no documented cases of disease transfer. It is unclear how one would demonstrate this, other than with large-scale manipulative experiments combined with genetic markers.

Interactions between Pathogens

Because they cause skin damage and impair the immune system, being infected with lice may increase the fish's susceptibility to other pathogens, including *Loma* (62) and ISAV (3). Infections by lice (or being in any disease state) may also be expected to increase susceptibility to adverse environmental conditions, such as the higher water temperatures associated with climate change. It is also noteworthy that co-infection (i.e., simultaneous infection by more than one pathogen) is one of the factors selecting for increased virulence (see the following section).

Finally there is some evidence that sea lice can act as a vector for bacteria (2) and viruses (30), transmitting these pathogens from fish to fish as the lice switch hosts, a not uncommon behaviour (10).

The Red Herring of Endemism

It is sometimes claimed that because a particular disease is already found in wild salmon (i.e., is endemic), its presence on farmed salmon is not a threat to the wild fish. This is not necessarily the case. Because of the large numbers of hosts in close proximity in ONPs, lice, viral and other pathogen populations can grow to very large sizes - a process called bioamplification - shedding millions of infective stages (lice) or copies into the local environment outside the farm, where they can infect wild fish. Additionally, conditions inside the farm are exactly those which evolutionary theory predicts will lead to selection for increased pathogen virulence, i.e., an increased negative effect on its host (36). Although evolutionary processes like this will take several generations, the generation time of these pathogens is short. In fact there is considerable evidence that evolutionary change has happened in aquaculture facilities: ISAV apparently mutated to a more virulent form in Norwegian net pens (53), as did the bacterium *Flavobacterium columnarae* (73). Of particular relevance here, Leps sampled from farms cause more skin damage to their hosts, and cause greater growth reduction, than do lice sampled from wild fish (78). Although evolutionary processes like this will take several generations, the generation time of these pathogens is short. The result is that what comes out of ONPs can be much more dangerous to wild salmon than the pathogens that the wild salmon passed to the farmed Atlantic salmon in the first place.

This is further exacerbated by the farms disrupting what has been called "migratory allopatry" (44), meaning that returning adult wild salmon that may be infected with sea lice or other pathogens do not interact directly with juveniles on their way to sea, because they are not in the same place at the same time. This prevents pathogens on the former from infecting the latter. However, placing ONPs on the migration route allows for the pathogens to find a readily available host population in the fall, and to retain and grow the pathogen population over the winter, providing a source of infection for juvenile fish

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passing by the farms in the spring. The fact that these fish are small, and in the case of very young pink and chum salmon, without scales, means they're less able to cope with infection, making the problem worse.

Consequences of Infection for Individuals

Sea lice and diseases may in some cases kill their salmon hosts directly, through stress and physiological dysfunction (12, 76, 6). For example, skin damage caused by lice may lead to osmoregulatory failure. However, it is widely believed that they more frequently make their hosts more susceptible to other mortality agents, particularly starvation and predation.

Recent research suggests that heavy infections with *Caligus* can reduce the ability of juvenile sockeye salmon to compete for food and thus reduce their growth (25, 26). This is important because salmon biologists have known for a long time that smaller fish in a cohort have a much lower probability of survival to adult return (e.g. 5), perhaps due in part to being more likely to be eaten by predators (77).

Predators may have an even more direct effect on salmon infected with sea lice because the lice *per se* may make them more susceptible to predators, as has been shown for pink and chum salmon fry (47). The mechanism for this is not entirely clear but may involve compromised swimming ability (50, 63), less attentiveness to predators while concentrating on feeding (47), and/or altered schooling behaviour (47) or surface activity (82).

Very little research of this sort has been done on fish infected with other disease agents but having BKD makes chinook salmon more vulnerable to predators (54), and Rhinoceros auklets (a seabird) have more sockeye infected with the myxozoan *Parvicapsula* in their diets than would be expected based on the proportion such fish make up of the population (56). Also, Chilko sockeye smolts showing signs of viral infection (including IHNv) have a much lower chance of surviving downstream migration to the mouth of the Fraser River than do their uninfected counterparts (31), perhaps due to in- stream predation. The source of these infections in not known with certainty, though ONPs are certainly one possibility.

The implications of these findings are extremely important. If generally true it means that juvenile fish heavily infected with lice, or fighting off viral infection, may be quickly removed from the population, ending up either in the guts of predators or sinking to the sea floor. As a result, it will be most unlikely that sampling of wild fish populations will find many of them to be infected, as only the survivors will still be present, thereby greatly underestimating the impact of ONPs. It also means that laboratory studies in benign environments devoid of predators (e.g., 35) will greatly overestimate the threshold level of infection likely to cause death. Thus (35) found that 7.5 lice per gram in small juvenile pink salmon were necessary to cause death in the lab, yet found few of such fish in the field, implying that lice were not a major cause of mortality (34). The fallacy of this argument should be apparent. It was clearly articulated 20 years ago (52):

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"In contrast to cage or tank situations, sick fish in the natural environment that

show any abnormal behaviour are likely to be rapidly removed from the area by predators and any random samples of fish taken will almost inevitably show only healthy animals, those with non-pathogenic infection levels or those with benign types of disease". (McVicar 1997)

Population Consequences Worldwide Picture

A global assessment (20) suggests that local native salmonids are impacted negatively wherever there are fish farms (see also 13). A particularly well-documented case study of the effect of sea lice has recently been provided for sea trout in Europe, based on many years of research in Ireland, Scotland and Norway (76). As well, Atlantic salmon returns to the Erriff River in Ireland are 50% lower in years following high lice levels on farms (70).

It should be noted that since it is possible (and perhaps even highly likely) that fish infected by lice may be co-infected with other pathogens, some of the negative effects attributed to lice may be due to bacteria or viruses, which are harder to detect and may not have even been assayed. This caveat applies equally to the Broughton Archipelago lice studies to be described next.

BC

Broughton Archipelago pink salmon: An argument raged in the literature for several years over whether Broughton pink salmon populations were being severely impacted by sea lice. Early predictions (45) that lice would cause local pink salmon extinction if downward populations trends continued proved untrue, but this was likely due in part to changes in louse management practices (timing of anti-louse treatment prior to the wild salmon migration window; 66). In and of itself, this would suggest an impact of lice on wild fish. One study by the Provincial pathologist (51) was unable to find an effect of farmed salmon louse levels on pink salmon survival, but more thorough and powerful analyses (46, 43) revealed a significant effect on recruitment. Worryingly, lice levels on wild salmon in the Broughton have recently increased; this may be due to a combination of warmer water and less well-timed treatment on the farms (4).

Coho salmon: There is evidence that Broughton Archipelago coho salmon populations are also negatively impacted by salmon farms (9). Like the pinks, coho probably pick up lice directly from the farms, but they also pick up lice indirectly when consuming parasitized pink salmon (8).

Chum salmon: Curiously, although chum salmon fry are often just as heavily parasitized by lice as are pink fry, their survival does not seem to be negatively affected to the same extent (67). It is believed that this may be due to predators concentrating their attention on the more preferred, and now vulnerable, pinks, thereby reducing predation pressure on the chum.

Fraser sockeye: An analysis conducted for the Cohen Commission, and subsequently published (11), suggested that the number of fish in the ONPs passed by migrating

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sockeye smolts was a predictor of subsequent adult returns, i.e., more fish in the pens led to lower sockeye returns. But this was true only when competition with pink salmon in the open ocean was likely to be intense. Interestingly, this result is consistent with the above-mentioned finding that lice compromise sockeye competitive abilities (25).

Correlation, Causation and Experimentation

Studies such as that showing that heavily liced fish are less able competitors (25) can justly be criticized for assuming that the correlation implies causation. It may be that lower food intake compromises the fish's ability to avoid infection, or that inherently low quality fish are both competitively inferior and more vulnerable to lice. However, if a causal hypothesis based on a correlation leads to a prediction that can be confirmed by further observation, or if several correlations triangulate at the same cause from different angles, one can begin to have some confidence that the proposed causal mechanism is correct. This is especially true if the proposed cause aligns with known biological principles. Thus correlations provide important data in several fields, including epidemiology – and salmon epidemiology is essentially what we are dealing with here.

However, while it would be unwise to discount correlational evidence, a better way forward is through controlled experiments. This is not always possible, particularly at the individual level of analysis; it would require placing predetermined numbers of lice on randomly selected clean fish, and no one has devised a way to do this yet. But there are two kinds of experiments that have been conducted at the population level. The first is fallowing. Fallowing of farms during late winter and spring has been shown to reduce lice infection of sea trout in Ireland and increase their survival (21). A similar experiment was conducted in BC in 2003, when the ONPs along an entire migration corridor in the Broughton Archipelago were left fallow during the spring migration of wild fry. This resulted in an increase in adult returns the following year (59; see also 61) A problem with a study of this sort is the lack of replication, meaning that the improved survival in that year could have been due to some other factor favouring the fish, such as increased food availability in the ocean or reduced salinity lowering survival of the lice (33).

A far stronger experimental result has recently been reported. SLICE (emamectin benzoate) is used to rid farm salmon of sea lice. It has also been applied to batches of hatchery Atlantic salmon as a chemotherapeutic in the hope of reducing their likelihood of picking up lice when passing fish farms. A meta-analysis of 118 separate experimental releases of this sort leaves no doubt that it is effective in increasing survival (79; see also 72) and implicates ONP-origin lice as the cause of reduced survival in the absence of treatment. An interesting result of the analysis was that the impact of the anti-parasiticide, and by inference of lice, was stronger when the survival of the untreated control group was poorest. The treated salmon were

1.7 times more likely to survive as the untreated ones under such conditions. Like the analysis conducted on sockeye for the Cohen Commission (11) this suggests that the impact of ONPs may be greatest when other biotic and abiotic conditions are less favourable for wild salmon survival.

No similar experiments have been conducted with lice chemotherapeutics in BC and no such experiments have been conducted on bacteria and viruses. This would be a very worthwhile research project.

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Experiments are difficult to conduct in large field systems with numerous uncontrollable variables, so researchers are sometimes forced to "experiment in silico" with mathematical models. Models describe the workings of a system to the extent it is currently understood, and allow manipulation of variables to see the consequences. They can focus attention on gaps in knowledge and the simulation results should be viewed as hypotheses for further testing; they can also suggest improved management practices. The extensive literature on salmon-sea louse epidemiological models has recently been reviewed (27). One of the outcomes was a greater realization of the importance of incorporating spatial structure, i.e., spacing and interactions between farms along a migration route.

Other Potentially Negative Impacts of ONPs Escapes

The recent escape of something like 150,000 farmed Atlantic salmon from an aging ONP in Washington State, and their subsequent dispersal and capture far from the site, has cast the spotlight on another potential risk to wild salmon. It is known that farmed Atlantics can survive in the wild and may have established permanent populations in BC streams (80, 19). Because they are not closely related to Pacific salmon, there is very little likelihood of interbreeding and loss of genetic identity (with the possible exception of the Clayoquot Sound area where the farms raise chinook salmon, wild populations of which are found in local streams; 40). Rather, the risks come from their potential for competing with wild juvenile Pacific salmon and steelhead in streams, and possibly from disease transfer. Studies on the former suggest that while competition is possible it is unlikely to have severe consequences (summarized in 75). There has been no scientific study of disease transfer from escapees in BC, though it is known that some diseases can transfer from Atlantic to Pacific salmon sharing the same water, as could occur in streams (23, 41), and escaped Atlantic salmon are suspected of transmitting furunculosis (a bacterial disease) to wild salmon and trout in Norway (32).

ONPs have other negative consequences for the ecosystems that house them, including:

- attraction of wild forage fish (such as herring) and salmon and incidental harvesting of them ;

- pollution of the seafloor immediately below the pens with faeces and excess food;

- pollution from plastic debris (29), chemical agents (e.g. those used to clean nets; 7), diesel (spilled at a farm in the Broughton Archipelago in early 2017) and antibiotics;

- reduction of local crustacean populations as a result of SLICE spill-over;

- reduction of predator populations, including seals and sea lions, due to shooting. Several of these are discussed in my report to the Cohen Commission (15), but are not treated in detail here because they are unlikely to have significant effects on wild salmon stocks comparable to the potential impacts of parasites and diseases.

Concluding Remarks

In my opinion the risk to wild salmon from sea lice produced in ONPs is unambiguous. Lice have been shown to reduce productivity of both wild pink and coho salmon populations in the Broughton Archipelago, and there is no reason to think they are not having similar effects elsewhere on the BC coast. The mechanisms by which lice impact individual survival are well understood, and these individual and population level effects have been found consistently throughout the world and are supported by large-scale experiments.

Experience in the Broughton Archipelago suggests that lice impacts on wild salmon can be mitigated by appropriate control strategies on the farms, particularly the timing of parasiticide treatment. However, there is concern that lice may evolve resistance to SLICE and other chemicals used to control them, as is happening elsewhere (1). Ironically, it seems that a large wild fish population may help to maintain the efficacy of SLICE and delay the evolution of resistance (42), meaning that the preservation of healthy wild salmon populations is in the salmon farmers' self interest!

PRV (and HSMI, the disease it causes) has been implicated in the heavy pre-spawning mortality of Fraser River sockeye salmon. Additionally, it has been shown that productivity of these stocks depends in part on the number of Atlantic salmon in the ONPs that the smolts pass on their northward migration to the open ocean. While we do not know what it is about the farms that underlies this latter relationship, pathogen transmission remains the most likely explanation. It is tempting to speculate that PRV may be involved but we don't yet know the source of the PRV with certainty.

The case is not so clear for other pathogens. While harmful pathogens – including viruses, bacteria, myxozoans and microsporideans - are certainly present in the ONPs, and there is evidence that some can be passed to wild salmon with harmful effect, we cannot say with certainty that any wild salmon population has declined because of them.

Research on these topics is badly needed, and indeed is ongoing, but in the meantime it seems that the evidence of risk to wild salmon is sufficient that the precautionary principle should be invoked, and Governments should mandate and support the aquaculture industry's move from ONPs to land-based closed containment production systems.

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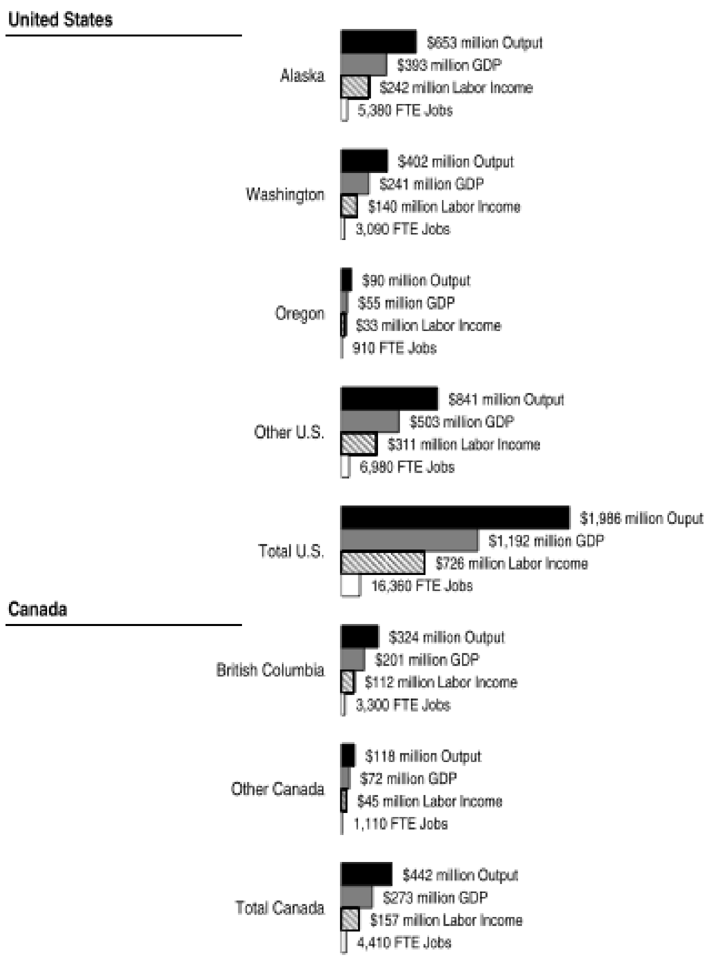
Attachment 2:

Exhibit A: Commercial Salmon Industry - Average 2012 to 2015 Economic Impacts*



* *Total impacts including direct industry, indirect supplier and induced consumer respending impacts for the regions in which the impacts occur (which may differ from where the fisheries occur). Values are expressed in USD.*

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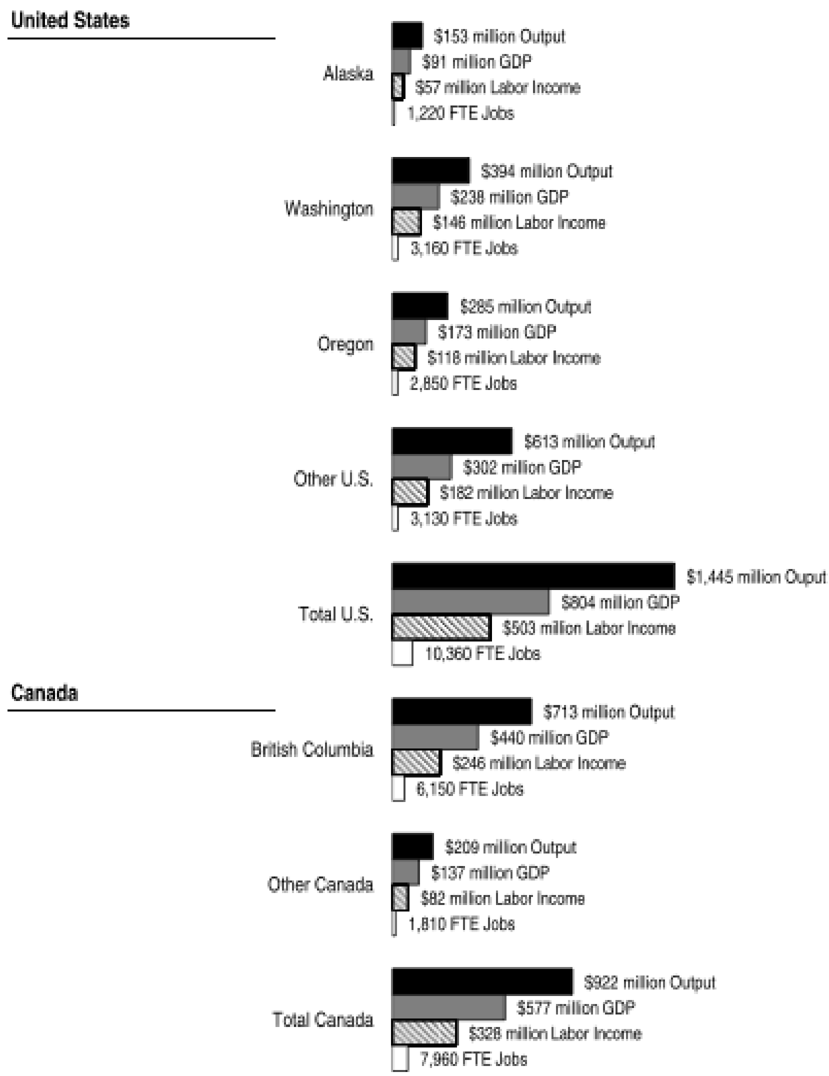
Exhibit B: **Recreational Salmon Industry - Average 2012 to 2015 Economic Impacts**



* *Total impacts including direct industry, indirect supplier and induced consumer respending impacts for the regions in which the impacts occur (which may differ from where the fisheries occur). Values are expressed in USD.*

Attachment 3: Timeline for PRV Fish Health Impairment Potential*

Prepared by R. Routledge, Professor Emeritus, Simon Fraser University

- **2004** Kongtorp *et al.* (a[91],b[92]): First case definition of HSMI and demonstration that it is infectious.
- **2006** Watanabe *et al.*[93]: Early evidence on potential viral cause of HSMI.
- **2009** Kongtorp and Taksdal[94]: Risks of spreading HSMI by transferring apparently healthy fish.
- **2010** Palacios *et al.*[95]: PRV discovered - reported as viral precursor of HSMI.
- **2012** Finstad *et al.*[96]: Further evidence that PRV causes HSMI.

  Kristoffersen *et al*.[97]: Risk of long-distance dispersal of PRV over 50-100 km.

  Garseth *et al*. (a[98], b[99], c[100]): PRV widely dispersed (without HSMI) in wild Atlantic salmon, can spread from farm to wild salmon, sea-trout could play role in pathogen exchange with wild Atlantic salmon.

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82 Kongtorp, RT, Kjerstad, A, Taksdal T, Guttvik, A, and Falk, K. 2004a. Heart and skeletal muscle inflammation in Atlantic salmon, Salmo salar L.: a new infectious disease. J. Fish Dis. 27: 351-358.

92 Kongtorp RT, Taksdal T, and Lyngøy A. 2004b. Pathology of heart and skeletal muscle inflammation (HSMI) in farmed Atlantic salmon Salmo salar. 2004b. Dis Aquat Org 59: 217–224.

93 Watanabe K, Karlsen M, Devold M, Isdal E, Litlabø A, and Nylund A. 2006. Virus-like particles associated with heart and skeletal muscle inflammation (HSMI) Dis Aquat Org 70: 183-192.

94 Kongtorp RT, and Taksdal T. 2009. Studies with experimental transmission of heart and skeletal muscle inflammation in Atlantic salmon, Salmo salar, L. J. Fish Dis 32: 253-262

95 Palacios G, Lovoll M, Tengs T, Hornig M, Hutchison S, Hui J, Kongtorp R, Savji N, Bussettii AV, Solovyov A, Kristoffersen AB, Celone C, Street C, Trifonov V, Hirschberg DL, Rabadan R, Egholm M, Rimstad E, and Lipkin WI. 2010. Heart and skeletal muscle inflammation of farmed salmon is associated with infection with a novel reovirus. PLoS ONE 5(7): e11487. doi:10.1371/journal.pone.0011487

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97 Kristoffersen AB, Bang Jensen B, Jansen PA. 2013. Risk mapping of heart and skeletal muscle inflammation in salmon farming. Prev Vet Med. 2013 Apr 1;109(1-2):136-43. doi: 10.1016/j.prevetmed.2012.08.012. Epub 2012 Sep 5. PubMed PMID: 22959429.

98 Garseth AH, Biering E, Aunsmo A. 2013a. Associations between piscine reovirus infection and life history traits in wild-caught Atlantic salmon Salmo salar L. in Norway. Prev Vet Med. 2013 Oct 1;112(1-2):138-46. doi: 10.1016/j.prevetmed.2013.06.007. Epub 2013 Jul 29. PubMed PMID: 23906390.

99 Garseth ÅH, Ekrem T, Biering E. 2013b. Phylogenetic evidence of long distance dispersal and transmission of piscine reovirus (PRV) between farmed and wild Atlantic salmon. PLoS One. 2013 Dec 11;8(12):e82202. doi: 10.1371/journal.pone.0082202. eCollection 2013. PubMed PMID: 24349221; PubMed Central PMCID: PMC3859594.

- **2014** Finstad *et al*.[101]: Discovery that PRV first proliferates in red blood cells with potential effects on fish health.

  Miller *et al*.[102]: Shortened survival for PRV-infected sockeye salmon returning to Chilko Lake.

  Marty *et al*.[103]: Heart lesions in BC not likely caused by PRV. PRV may not cause HSMI.

- **2015** Wessel *et al*.[104]: Technical progress on molecular-level functioning of PRV.

  Wessel *et al*.[105]: More definitive evidence that PRV can replicate in red blood cells.

  Olsen *et al*.[106]: HSMI-like disease and anemia along with PRV-like virus in rainbow trout.

  Dahle *et al*.[107]: Found major phenotypic changes in PRV-infected red blood cells in Atlantic salmon. Functional consequences unexplored.

  Bjørgen *et al*.[108]: Elevated PRV levels in damaged versus undamaged muscle cells. Further evidence that PRV causes HSMI.

  DFO[109]: PRV in BC farmed and wild salmonids. No reports of HSMI in BC.

- **2016** Siah *et al*.[110,111]: HSMI not in BC. PRV widespread, long-present in BC.

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[100] Garseth ÅH, Fritsvold C, Opheim M, Skjerve E, and Biering E. 2013c. Piscine reovirus (PRV) in wild Atlantic salmon, Salmo salar L., and sea-trout, Salmo trutta L.in Norway. J Fish Dis.. 36: 483-493.

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[107] Dahle MK, Wessel Ø, Timmerhaus G, Nyman IB, Jørgensen SM, Rimstad E, Krasnov A. Transcriptome analyses of Atlantic salmon (Salmo salar L.) erythrocytes infected with piscine orthoreovirus (PRV). Fish Shellfish Immunol. 2015 Aug;45(2):780-90. doi: 10.1016/j.fsi.2015.05.049. Epub 2015 Jun 6. PubMed PMID: 26057463.

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[109] DFO. 2015. Assessment of the Occurrence, Distribution and Potential Impacts of Piscine Reovirus on the West Coast of North America. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/037.

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[111] Erratum in above publication: PLoS One. 2016 Oct 12;11(10):e0164926. PubMed

Madhun *et al*.[112]: Low prevalence and intensity of PRV in wild sea trout.

Garver *et al*. (a[113], b[114]): BC strain of PRV can be transmitted to sockeye and chinook salmon, but does not cause HSMI or jaundice syndrome.

Haatveit *et al*.[115]: Molecular-level evidence related to PRV replication in red blood cells.

Godoy *et al*.[116]: HSMI in Chilean farmed Atlantic salmon. Heart lesions with PRV-like virus found in Chilean farmed coho salmon.

Takano *et al*.[117]: PRV-like virus causes blood disease, EIBS, in coho salmon.

Lund *et al*.[118]: PRV can help Atlantic salmon fight a SAV infection.

Polinski *et al*.[119]: Evidence of a limited early response to PRV infection in sockeye salmon, independent of co-infection with IHNV.

Wiik-Nielsen *et al*.[120]: Evidence that PRV is higher when HSMI symptoms observed in farmed Atlantic salmon. Evidence also of complex co-infection dynamics.

Morton and Routledge[121]: Review of aquaculture-related risk factors (including PRV) for wild Pacific salmon.

PMID: 26536673; PubMed Central PMCID: PMC4633109.

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[118] Lund M, Røsæg MV, Krasnov A, Timmerhaus G, Nyman IB, Aspehaug V, Rimstad E, Dahle MK. 2016. Experimental piscine orthoreovirus infection mediates protection against pancreas disease in Atlantic salmon (Salmo salar). Vet Res. 2016 Oct 21;47(1):107. PubMed PMID: 27769313; PubMed Central PMCID: PMC5075195.

[119] Polinski MP, Bradshaw JC, Inkpen SM, Richard J, Fritsvold C, Poppe TT, Rise ML, Garver KA, Johnson SC. De novo assembly of Sockeye salmon kidney transcriptomes reveal a limited early response to piscine reovirus with or without infectious hematopoietic necrosis virus superinfection. BMC Genomics. 2016 Nov 2;17(1):848. PubMed PMID: 27806699; PubMed Central PMCID: PMC5094019.

[120] Wiik-Nielsen J, Alarcón M, Jensen BB, Haugland Ø, Mikalsen AB. Viral co-infections in farmed Atlantic salmon, Salmo salar L., displaying myocarditis. J Fish Dis. 2016 Dec;39(12):1495-1507. doi: 10.1111/jfd.12487. Epub 2016 May 5. PubMed PMID: 27146423.

[121] Morton A, Routledge R. 2016. Risk and precaution: salmon farming. Marine Policy 74: 206-212.

- **2017** Di Cicco *et al*.[122]: HSMI in BC. Strengthened connection between PRV and HSMI. Suggestion that DFO's Fish Health and Surveillance Program is not adequate to consistently diagnose HSMI.

  Haatveit *et al*.[123]: Initial acute PRV infection in red blood cells lasts only 1-2 weeks before subsiding.

  Wessel *et al*.[124]: Confirmation that PRV can cause HSMI on its own.

  Miler *et al.*[125]: Correlational evidence that PRV may cause jaundice in farmed chinook salmon.

  Purcell *et al.*[126]: Evidence of PRV prevalence in coho and chinook salmon in Washington and SE Alaska.

  Kibenge *et al.*[127]: Critique of Siah *et al.* (2016).

  Morton *et al.*[128]: Correlational evidence linking salmon aquaculture to PRV dynamics in wild Pacific salmon and PRV to weakened ability for Pacific salmon to return to higher-elevation spawning grounds.

**Descriptions selectively highlight major features of key papers related to the health impairment potential of PRV, and are not intended as full summaries.*

[122] Di Cicco E, Ferguson HW, Schulze AD, Kaukinen KH, Li S, Vanderstichel R, Wessel Ø, Rimstad E, Gardner IA, Hammell KL, and Miller KM. 2017. Heart and skeletal muscle inflammation (HSMI) disease diagnosed on a British Columbia salmon farm through a longitudinal farm study. PLoS ONE 12(2): e0171471. doi:10.1371/journal. pone.0171471

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[124] Wessel Ø, Braaen S, Alarcon M, Haatveit, H, Roos N, Markussen T, Tengs T, Maria K. Dahle MK, Rimstad E. (2017) Infection with purified Piscine orthoreovirus demonstrates a causal relationship with heart and skeletal muscle inflammation in Atlantic salmon. PLoS ONE 12(8): e0183781. https://doi.org/10.1371/journal.pone.0183781

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[127] Kibenge MJT, Wang Y, Morton A, Routledge R, Kibenge FSB (2017) Formal comment on: Piscine reovirus: Genomic and molecular phylogenetic analysis from farmed and wild salmonids collected on the Canada/US Pacific Coast. PLoS ONE 12(11): e0188690. https://doi.org/10.1371/journal.pone.0188690

[128] Morton A, Routledge R, Hrushowy S, Kibenge M, Kibenge F (2017) The effect of exposure to farmed salmon on piscine orthoreovirus infection and fitness in wild Pacific salmon in British Columbia, Canada. PLoS ONE 12(12): e0188793. https://doi.org/10.1371/journal.

Appendix 10

Council Member View on Risk — Perspective 3

Inclusion does not imply endorsement by council

Appendix 10 – Council Member View on Risk — Perspective 3

It was noted in Section 4 of this report that MAACFA members agree that risk to wild salmon populations presented by salmon net-pen aquaculture is the primary overarching issue and managing risk is the basis for developing our advice.

In this appendix Jeremy Dunn elaborates on the perspective of risk, summarized as Perspective 3 in the Council's Report and Recommendations. His views are presented as submitted for inclusion in the report's appendices for information and this does not imply endorsement by council.

Assessing the Risk of Harm from Salmon Farms to B.C.'s Wild Salmon Populations

This appendix presents a significant weight of peer-reviewed evidence (54 citations) to support the perspective that net-pen salmon farms do not pose a greater than minimal risk of serious harm to B.C.'s wild salmon as expressed in Perspective 3 on page 5 of the MAACFA Final Report. Furthermore, the body of evidence supporting this perspective and highlighted in this report, provides a high level of certainty on the issue.

- B.C.'s farm-raised salmon stocks are healthy. Aquaculture veterinarians utilize the same proven approaches and strategies used across all food animal and production medicine. Results from the B.C. Ministry of Agriculture's Animal Health Centre show that less than 1% of B.C. farm-raised Atlantic salmon die of diseases that might be infectious to wild Pacific salmon. Among the other 99% of farm-raised salmon, 90% survive and 9% die of other causes (mostly environmental).

- A fundamental component of fish health management is prevention – something that is readily apparent in every stage of B.C. salmon production, from egg to plate. By implementing fish health and husbandry practices, which optimize the health and welfare of fish, salmon farming companies maximize the productivity of their fish and minimize fish health risks; the need for medical intervention, such as antibiotic treatment is also greatly decreased.

- Apart from the potential interactions between farm-raised and wild salmon, there is significant evidence that wild salmon populations experience natural oscillations in returns from year to year, and this is also apparent in regions without salmon farms.

To assess the risk of harm to B.C.'s wild salmon populations by the activity of raising salmon in ocean-based net-pen operations, there are a number of factors for consideration, which will be reviewed here.

1. **Farm-raised Salmon Health:** The ability to control health of farm-raised salmon, to a high degree, by both by the industry and the regulator.

2. **Managing Known & Perceived Risks. Assessing evidence on:**
   - wild and farm-raised salmon populations co-existing, sustainably
   - pathogen interactions between farm-raised and wild salmon
   - sea lice interactions between farm-raised and wild salmon
   - the risks of escapes to wild salmon
3. **Efforts to Date in Quantifying Risk:** The body of internationally respected, peer-reviewed science and consideration on each of these factors, and results of Forums and Inquiries that have investigated this matter.

Farm-Raised Salmon Health in B.C.

The importance of healthy stocks in the food production industry cannot be overstated. Salmon farmers do everything in their power to proactively maintain optimal stock health. Management measures are tailored to the farming environment and perceived and known health risks. The success of salmon producers is directly related to their ability to produce healthy, productive fish and to maintain a high level of health and survival throughout the entirety of the salmon's life cycle.

Fish health departments are led by veterinarians and trained staff who undertake extensive fish health programs. Aquaculture veterinarians utilize the same proven approaches and strategies used across all food animal and production medicine. Veterinarians routinely conduct fish farm site visits to assess fish health at different stages of production, and to ensure best fish health management practices are followed. A fundamental component of fish health management is prevention – something that is readily apparent in every stage of B.C. salmon production, from egg to plate. By implementing fish health and husbandry practices which optimize the health and welfare of fish, salmon farming companies maximize the productivity of their fish and minimize fish health risks; the need for medical intervention, such as antibiotic treatments is also greatly decreased. Prevention of fish health issues and disease begins with broodstock, the source of all eggs, and eventually fish, grown by salmon producers. Broodstock are very closely monitored and managed, and are screened for a number of pathogens before their eggs can be used in production. The eggs of any broodstock which test positive are discarded in order to prevent any risk of disease transfer to the next generation of fish.

Another important aspect of prevention in veterinary medicine and animal production is biosecurity. Biosecurity refers to procedures and strategies developed and instituted to prevent the introduction or spread of biological agents to, or between, a population of animals. Salmon farming companies have biosecurity Standard Operating Procedures in place, developed by veterinarians and fish health staff, to do just that. Strict cleaning and disinfection protocols, as well as movement controls of people and equipment are key elements of biosecurity. There are also practices that are designed to contain the spread of pathogens from a farm once a disease has been detected (e.g. treatment and management options, early eradication, viral management plan with enhanced movement control, and communications among companies and with regulatory bodies).

Veterinarians also direct the vaccination of stocks for common bacterial and viral pathogens that occur naturally in the Pacific marine environment: Furunculosis, Vibriosis, Moritella viscosa, Bacterial Kidney Disease (BKD), Enteric Red Mouth, and Infectious hematopoietic necrosis (IHN) (BCSFA, 2017). Vaccine research is currently underway for two bacterial diseases endemic to B.C.: Yellow Mouth (Tenacibaculosis) and Salmonid Rickettsial Septicaemia (SRS) (BCSFA, 2017).

By vaccinating fish and preventing pathogen outbreaks in farm-raised salmon, the risk of disease transmission between farm-raised salmon and wild salmon is significantly reduced. Additionally, by giving fish a better start right out of the hatchery, understanding how best to reduce any stress while in the ocean, and paying more attention to potential consequences of excessive antibiotics usage, B.C. salmon farmers have steadily reduced the level of antibiotics used over the past two decades (Morrison and Saksida, 2013).

In addition to utilizing prevention strategies, thorough fish health monitoring and testing is also performed by fish health and farm staff. Veterinarians monitor and screen fish throughout the entire production cycle, including eggs, fry, and parr in freshwater, and smolts to harvest sized fish and broodstock in saltwater. A number of fish farms in B.C. have implemented health management practices which are beyond the requirements of their regulators. One example is seen with sea lice counts; though there is a requirement for farms to conduct counts biweekly during the juvenile salmon outmigration and monthly for the remainder of the year, a large portion of the farms in B.C. now conduct weekly sea lice counts. This increased frequency gives veterinarians more accurate and up-to-date information on which to base management decisions.

Fish farm employees are trained to identify emerging health issues in salmon stocks and management plans are in place to respond accordingly. Extensive fish health and production data is collected daily by individual fish farms; this data is regularly analysed by veterinarians and fish health staff to identify factors or trends which may indicate potential fish health concerns. Based on this data, necessary changes can be implemented to prevent or mitigate these concerns.

In cases where medical intervention is required, diligent fish health monitoring and data analysis allows veterinarians to identify issues quickly and to act in a timely and effective manner. The B.C. salmon industry has been very proactive in developing and utilizing alternative treatment options, despite the regulatory challenges which the industry has faced.

The industry continues to make improvements in the area of fish health, conducting and supporting a great deal of internal and external R&D. The increased investment in fish health management for farm-raised salmon has been working. This is evidenced through years of data from government fish health audits (Marty, 2015).

DFO's Assessment of the risk to Fraser River Sockeye Salmon due to Infectious Haematopoietic Necrosis (IHN) on Atlantic Salmon farms in the Discovery Island, (the first of several risk assessments which the Department is developing on the risks that are posed by farm-raised salmon to the health of Fraser River Sockeye), highlighted the best management practices and standard operating procedures that are implemented by the B.C. salmon farming industry to prevent, monitor and manage pathogens and disease. The protocols in place served as a major weight of evidence in the ultimate determination that the salmon farming industry is not posing greater than minimal threat to wild Sockeye salmon in terms of IHN.

Initiated in 2003 by the B.C. government, the current fish health audit program is administered as a requirement of licence by Fisheries and Oceans Canada (DFO). Government fish health technicians conduct up to 30 onsite farm audits per quarter, examining mortality records and sampling fresh carcasses for diagnostic evaluation. The program samples dead fish because they are more likely to have diseases of concern than the living fish. Samples from 600 – 800 fish per year are analyzed by bacteriology, histopathology (nine organs), and PCR analysis (for five pathogens). The B.C. Ministry of Agriculture's Animal Health Centre in Abbotsford has always conducted the bacteriology and PCR analysis for these samples. Histopathology has been done by the Animal Health Centre during all years except for 2012 and 2013 (Marty 2015).

Results from the B.C. Ministry of Agriculture's Animal Health Centre show that less than 1% of B.C. farm-raised Atlantic salmon die of diseases that might be infectious to wild Pacific salmon. Among the other 99% of farm-raised salmon, 90% survive and 9% die of other causes (mostly environmental). From an epidemiological perspective, the potential for infectious disease to spread from sick farm-raised salmon to healthy salmon within the same farm is significantly greater than the potential for disease to spread from sick farm-raised salmon to wild salmon. Therefore, it is reasonable to estimate that farm-source diseases kill far fewer wild salmon per year than die from disease on a salmon farm. This is substantially less than the estimated natural mortality of young wild salmon of 3% **per day** or 50% mortality of juvenile Pacific salmon within two months of them entering salt water (Marty, 2015; Cohen, 2012).

In terms of surveillance of disease in farm-raised and wild salmon, the Canadian Food Inspection Agency monitors for aquatic animal diseases (three federally reportable aquatic diseases: IHN, pancreatic necrosis (IPN) and infectious salmon anaemia (ISA)). The Agency functions as the focal point for the collection, analysis and dissemination of surveillance data. Published reports on salmon disease surveillance in B.C. can be found online (CFIA, 2017). No current or historical evidence has been found to indicate the presence of IPN or ISA in B.C. salmon.

Managing Known & Perceived Risks

There are four areas of evidence important to consider in evaluating the certainty of knowledge on risks associated with ocean net-pen farming of Atlantic salmon to wild Pacific salmon in B.C.: 1) evidence to assess the ability of wild salmon populations to sustainably co-exist with salmon farms, 2) evidence on salmon pathogen interactions between wild and farm-raised salmon, 3) evidence on parasite (sea lice) interactions between wild and farm-raised salmon and 4) evidence on the risks posed by escapes from farms to wild salmon populations.

1. Evidence of wild and farm-raised salmon populations co-existing, sustainably

Since its beginnings in the 1970's salmon farms along B.C.'s coast have co-existed with wild salmon populations.

There is a large weight of peer-reviewed evidence to indicate that the population dynamics of wild salmon in B.C. are extremely complex, and large stochastic fluctuations in abundance are associated with multifaceted oceanographic and biological conditions and inter-salmonid species interactions (in addition to direct human impacts including commercial fishing and habitat management) (MBA, 2017).

There are several extensive data sets that show declines in stocks of Pacific salmon species in locations not influenced by salmon farms. One example is a recent annual report of the Pacific Salmon Commission (32nd PSC Annual Report, pg.31), which shows a significant downward trend in commercial Sockeye harvest data from the Alaska fishery between 1985 and 2016 (PSC, 2017). In B.C.'s coastal waters, Beamish et al.(2004) showed that production of both Pink and Sockeye salmon from the Fraser River occurred in trends that changed in relation to trends in climate. In 2010, there was a record high return for Sockeye salmon to the Fraser River, despite the collapse of the previous year which caused the initiation of the Cohen Commission.

In 2007, a paper by Krkosek reported that recurrent louse infections of wild juvenile Pink salmon were associated with salmon farms, placing the Pink salmon populations in the Broughton Archipelago on a path towards rapid local extinction. It was forecasted that if the outbreaks continued, local extinction was certain with a 99% collapse in Pink salmon abundance by 2014. The conclusions were contested (Riddell et al, 2008) observing that the predictions were inconsistent with Pink salmon returns to Broughton Archipelago. The model was eventually revised (Krkosek et al, 2011). In addition, adult Pink salmon returns to the study area in 2014 were approximately 3.9 times larger than in 2006. DFO Escapement data indicates that the three largest returns of Pink salmon to the Broughton Archipelago have occurred since the beginning of salmon farming in the region (Figure 1).

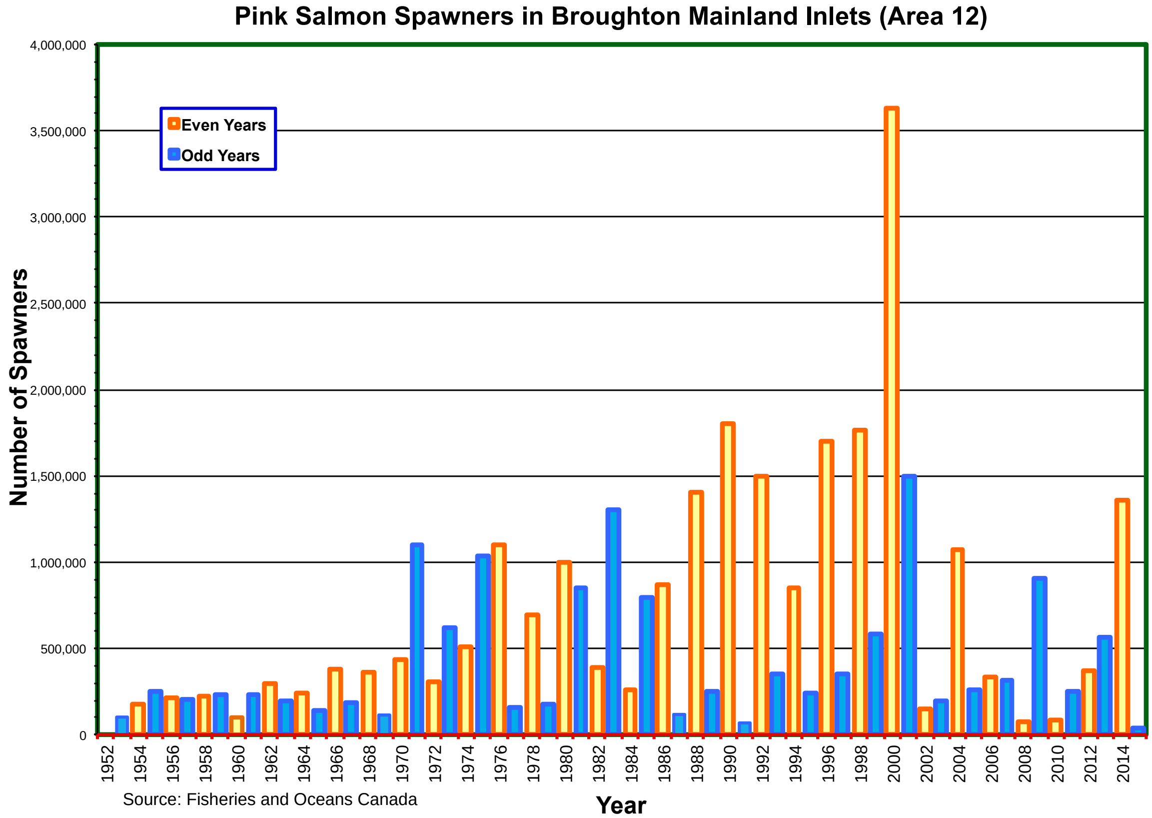

Figure 1. DFO Escapement data of Pink salmon in the Broughton Archipelago (1952-2014). (Adapted from DFO-NuSED, 2017).

In a 2011 publication, Alexandra Morton and colleagues assessed the health of wild Pink salmon populations in the Broughton Archipelago (an area with 20 salmon farms) compared to those of the B.C. central coast (a reference area to the north without salmon farms). They studied the abundance of sea lice in the environment preceding the juvenile salmon outmigration, as well as the abundance of lice on juvenile Pink and Chum salmon in the two regions. The authors concluded that "...there was no detectable difference in mean survival for the Broughton Archipelago relative to the central coast." (Morton et al, 2011, page 149). Additionally, A 2015 scientific publication from researchers based in the State of Washington and Simon Fraser University reported no relation between farm fish production in the Discovery Islands and Fraser River Sockeye salmon returns (Ruggerone and Connors, 2015). These studies are two examples of evidence to support that salmon farms do not present greater than minimal risk of serious harm to wild salmon.

2. Evidence on pathogen interactions of farm-raised and wild salmon

In assessing the risks of pathogens interactions between farm-raised and wild salmon, there are a few bodies of evidence to consider: 1) known pathogens of serious concern and management measures, 2) pathogens of emerging interest and associated research, and 3) the research on comparing the pathogens carried by wild and farm-raised populations.

Known Pathogens of Serious Concern

According to DFO's Fish Health Audit and Surveillance Summary program (DFO, 2018c), of all of the pathogens and diseases screened for, there are six of concern to wild Pacific salmon. Those are: Bacterial Kidney Disease (BKD), Enteric Redmouth (ERM), Furunculosis, Infectious Haematopoietic Necrosis (IHN), *Loma salmonae*, and Viral Haemorrhagic Septicaemia, North American Strain (VHS,NAS). These are the focus of this report, as other identified infections of farm-raised salmon identified by DFO's fish health audits are not highlighted as concern to wild salmon populations.

Bacterial Kidney Disease (BKD)

While susceptibility to disease varies among the salmonid species, *Oncorhynchus spp*. particularly *O. tshawytscha* (Chinook salmon) and *O. mykiss* (rainbow trout) are the most susceptible to BKD. BKD was first described during the 1930's in Atlantic salmon (*Salmo salar*) from the Dee River system in Scotland (Smith, 1964). Since that time, BKD has been reported in salmonids throughout North America, Western Europe, Chile, Japan and Iceland. *R. salmoninarum* can be transmitted vertically from females to progeny via eggs (Evelyn et al, 1986) and horizontally from fish to fish (Balfry et al, 1996). The B.C. salmon farming industry screens broodstock for BKD, and also vaccinates against the disease, reducing the incidence of BKD in farmed fish (Noakes, 2011), and therefore, the risk of disease being transferred between farm-raised and wild salmon.

Enteric Redmouth (ERM)

ERM is a freshwater disease of trout and salmon that is "self-limiting" in that it resolves in the marine environment. The disease has been diagnosed in many salmonid species in hatcheries, lakes and rivers in B.C. where the population of fish might serve as a reservoir for the bacterium *Yersinia rukeri*, which causes the disease (DFO, 2018c). Because of the extensive husbandry practices taken by the B.C. salmon farming industry around the health of their fish in the freshwater hatchery environment, the disease is well managed and is of no threat to wild populations.

Furunculosis

This disease has been historically diagnosed in salmonids and non-salmonid species in hatcheries, lakes, rivers and coastal marine environments in B.C., which can all serve as a reservoir for the bacterium *Aeromonas salmonicida*. Outbreaks are uncommon in the finfish aquaculture industry because this disease is vaccinated for in the hatchery environment. Therefore, the risk it may pose to wild salmon, from farm-raised populations, is minimal.

Infectious Heamatopoietic Necrosis (IHN)

Infectious Haematopoietic Necrosis (IHN) is a virus of the Pacific Ocean. In British Columbia, IHNv is endemic and can occasionally cause disease in juvenile Sockeye salmon, and rarely in Rainbow Trout/steelhead, Chum salmon and Chinook salmon (DFO, 2017). With increasing size and later life-stage, Sockeye salmon become less susceptible to IHN disease but are susceptible to carrying the infection. Atlantic salmon smolts are highly susceptible to IHN with a minimal infectious lethal dose that is 10-100 times lower than for Sockeye salmon smolts (DFO, 2017).

The routine fish health monitoring programs for B.C. salmon farmers include analysis of the health status of their stocks, and includes sampling for IHN. From 2001 – 2003, an IHN outbreak among farm-raised Atlantic salmon spanned 22 months and affected 36 farms, operated by 5 different companies (Saksida et al, 2006). The only IHN outbreak since then occurred in 2012, and it was limited to three farms, and one company, spanning 3 months (DFO, 2017). Cases were identified early and immediately reported to the Canadian Food Inspection Agency (regulator of OIE reportable aquatic diseases including IHN) and isolated the farm sites. The company also informed their farming colleagues and enacted a pre-determined action plan to manage the situation. Further, the company notified all required parties and additional stakeholders, such as community partners. The industry now voluntarily vaccinates all Atlantic salmon for IHNv and has a collaborative viral management plan in place to protect against and manage for future outbreaks.

A recent, peer-reviewed risk assessment conducted by DFO concluded that the risk posed to Fraser River Sockeye salmon abundance and diversity by IHNv infection attributable to Atlantic salmon farms in the Discovery Islands is **minimal** under current fish health management practices (DFO, 2017).

Loma Salmonae

This is a parasitic disease of Pacific salmon, which can cause respiratory distress and render fish susceptible to other infections. Atlantic salmon are resistant to the parasite. Fish exposed to the infectious form of the parasite may develop diseased gills and reactions in the internal organs. Temperatures impact the infectivity of the disease. It is considered to be a freshwater parasite, but infections can persist after fish are transferred to seawater (Kent et al, 1995). Kent et al (1995) suggested that *L. salmonae* is transmissible between Chinook salmon held in seawater. However, because Atlantic salmon are resistant to the parasite (Shaw et al, 2001), the risk of this parasite to wild salmon, posed by B.C. farm-raised salmon is low.

Viral Haemorrhagic Septicaemia, North American Strain (VHS, NAS)

The marine type of this disease found in at least four marine fishes of the North Pacific (genotype IVa) has been detected in farm-raised Atlantic salmon. Although VHS is a reportable disease, the endemic genotype found in the North Pacific is associated with low virulence, with no farm-to-farm spread. Pacific salmon are not affected, and mortality of Atlantic salmon is very low.

Evidence from Emerging Pathogen Research

Novel Pathogens

It is important to note that previously undescribed pathogens continue to be 'discovered' (as they have for many years) including some novel pathogens identified under the Strategic Salmon Health Initiative (SSHI, 2018). These endemic pathogens have not previously been described in part because they have not resulted in any significant disease of either wild or farmed fish and were of little interest from a practical perspective and because of advances in technology (such as used in SSHI) that enables screening for a broad range of pathogens. To characterize these endemic pathogens as exotic because they are 'novel' is incorrect and misleading.

Piscine reovirus (PRV) and Heart and Skeletal Muscle Inflammation (HSMI)

PRv and HMSI are active areas of research in part because the virus itself has not resulted in significant disease outbreaks in farm-raised salmon and HSMI-like clinical symptoms have been rare in samples of farm-raised salmon. Along the Pacific coast, PRv has been detected in both farmed and wild fish populations extending from the state of Washington north through B.C. to Alaska. While some researchers have claimed that PRv first arrived on the Pacific coast from Norway sometime around 2007, based on genetic analyses of archived samples held by DFO PRv has been present in salmonids on the Pacific coast for at least several decades and perhaps longer (Marty et al, 2015; Siah et al, 2015).

Although the B.C. strain of PRv is genetically similar to the Norwegian strain there are significant differences in the clinical expression of this pathogen in both farmed and wild Pacific salmon. Experimentation has demonstrated that after infection PRv can reach high levels in the blood and is capable of being present for many months. However, unlike the experience in Norway, all experimental exposures of the Pacific strain of PRv to Pacific and Atlantic salmon in B.C. have failed to induce either disease or mortality. This suggests PRv in B.C. has a low ability to cause disease (low virulence) for these species (Garver et al, 2016a; Garver et al, 2016b). Further, in a collaborative study led by researchers at the DFO Pacific Biological Station, it was revealed that sockeye salmon infected with PRv exhibit a remarkable lack of response to the virus at 2 and 3 weeks after infection even though substantial viral amplification occurred during this period (Polinski et al, 2016). Also, there are still many questions about the potential link between PRV and HMSI. In Norway, PRv has been present in fish the exhibit HMSI suggesting it may be a causative agent but other environmental factors and the presence of other pathogens may be necessary to cause disease leaving many important questions to be explored and researched. Virologists and experts in fish health are actively pursuing research in this area supported by the work of industry veterinarians and others.

Evidence that Atlantic salmon are not asymptomatic carriers of disease that might affect wild Pacific salmon

Over the past two decades, at least six scientific studies have been conducted in which Atlantic salmon sourced from commercial farmers were cohabited with various Pacific salmon species under controlled laboratory conditions (Johnson, 1993; Johnson and Albright, 1992; Garver et al, 2016; St-Hilaire et al, 2001; Sutherland et al, 2014; Traxler et al, 1993). The Pacific salmon in these experiments never developed unexpected disease from the Atlantic salmon, allowing researchers to conclude that that the Atlantic salmon were not carrying an unknown disease of concern to Pacific salmon. These studies and circumstantial evidence support the conclusion that Atlantic salmon are not asymptomatic carriers of a disease that affects Pacific salmon.

Additionally, to assess whether there is cross over between the types of pathogens carried by farm-raised and wild salmon, researchers examined disease in juvenile outmigrating pink salmon in 2007 and 2008 (Saksida et al, 2012). Concurrently, the B.C. Fish Health Auditing and Surveillance Program studied farm-raised salmon that died at farm sites (Marty, 2015). Results showed that the wild pink salmon had one set of lesions and parasites, while the farmed salmon had a different set; only sea lice were shared by both groups of fish.

3. Evidence on sea lice interactions of farm-raised and wild salmon

Sea lice have been historically observed to be a common parasite on wild Pacific salmon off the west coast of Canada (Kabata, 1973, 1979). The dominant louse species is *Lepeophtheirus salmonis*; this species has a characteristic seasonal peak starting in mid-autumn - winter and naturally waning in late spring – early summer. Fisheries and Oceans Canada’s conditions of license for marine finfish aquaculture contain monitoring and intervention requirements to minimize the potential exposure of wild and farmed fish to sea lice. Farmers of Atlantic salmon increase sea lice monitoring to every two weeks during the wild juvenile salmon out-migration period (March – June). Many farm sites monitor weekly through the out-migration period as this is a requirement of certification by the Aquaculture Stewardship Council (ASC, 2017). (Currently, 40% of B.C’s active Atlantic salmon farms are certified to the ASC standard, all farms have committed to achieve this standard by 2020). Some farm sites have chosen to monitor at this frequency year-round. Sites are required by regulation to treat or harvest their salmon if the maximum abundance reaches 3 motile *L. salmonis* per salmon during the juvenile salmon migration period. Pharmaceutical lice treatments administered in-feed have shown to manage the seasonal peak in lice on farm-raised Atlantic salmon (Morton et al, 2011). and no known mortality of a farm-raised salmon from sea lice infestation has been noted in B.C.

Salmon farmers and regulators are well informed on sea lice numbers on both farm-raised and wild fish. They have consistently been monitoring for sea lice monthly, and as mentioned, more frequently, at a minimum during the out-migration seasons, since the early 2000's. Additionally, on-going meta-analysis of data from several sea lice monitoring programs across the B.C. coast over a 17-year period (2001 – 2017) at the University of Prince Edward Island will represent the largest, single, integrated dataset of its kind in the world. See the below section on "*On-going Analyses*", for more information.

What is known about sea lice loads and mortality of juvenile salmon?

Controlled lab studies have shown that the level of natural (or innate) resistance to the sea lice species *L. salmonis* among juvenile salmon endemic to B.C. is species specific. For example, compared with the other four species of Pacific salmon, pink salmon are considered the most inherently resistant to sea lice, despite their tiny size when they migrate to sea (Jones et al, 2008). Based on trials, scientists (Jones et al,2008; Jones and Hargreaves, 2009) have estimated that the lethal infection level for pink salmon averaging less than 0.7 g was 7.5 sea lice/g. Other scientists (Nendick et al, 2011) have reported that the presence of a sea lice did not have a significant effect on swimming performance in pink salmon >1 g.

For sockeye salmon, a lab study (Jakob et al, 2013) which measured response of salmon during infections with *L. salmonis*, indicated that mortality due to lice increased with infection pressure (*i.e.* number of sea lice in the environment). Mortality was greatest in fish exposed to the highest number of sea lice in their tank environment (300 copepodids/fish). The mean sea lice density on mortalities was 0.52 lice/gram. However, authors cautioned the importance of considering infection pressure in this finding, as higher sea lice densities (>0.52 lice/gram) were noted in trials with lower infection pressure (sea lice/tank), and these did not result in mortality. Unfortunately, similar research is not available for other species of Pacific salmon (coho, Chinook and chum) but all have shown varying levels of resistance (Fast et al, 2002; Johnson and Albright, 1991).

Chum salmon, which have been known to carry higher levels of sea lice on average than most species, are thought to be most susceptible (Jones and Hargreaves, 2007; Sutherland et al, 2014). It should be noted that these Pacific salmon species (sockeye, coho, Chinook, and chum) are all much larger than pink salmon when they migrate to the sea (see Groot C and Margolis L (eds) Pacific Salmon Life Histories. UBC Press 1991, 564 p).

What is known about sea lice impacts on salmon populations?

Scientists considering effects on a population scale, (Jones and Hargreaves (2009)) assessed sea lice data collected in the Broughton Archipelago and used mortality estimates derived from controlled exposure studies. They estimated that salmon mortality related to sea lice ranged between 0 and 4.5% in the years 2005-2008 for the Broughton Archipelago. By comparison, mortality during a salmon's first 40 days in the marine environment from all sources, including sea lice, (Heard, 1991) is estimated at 55-77%. The Cohen Report estimated that the mortality rate for sockeye at the beginning of their migration was 3% per day (Cohen, 2012). Biotracking of individual juvenile sockeye salmon from their natal Chilko Lake to below the Discovery Islands revealed a similar range of overall mortality (Clark et al, 2016). Marty et al. (2010) examined wild/farmed and sea lice data over a 10-year period in the same area, and found that the productivity of wild pink salmon was not negatively associated with sea lice. Morton et al. (2011) made similar conclusions.

On-going Analyses – University of Prince Edward Island

On-going meta-analysis of data from several sea lice monitoring programs across the B.C. coast over a 17-year period (2001 – 2017) at the University of Prince Edward Island will represent the largest, single, integrated dataset of its kind in the world. These data have been collected from over 300 locations covering around 12 regions along the B.C. coast using consistent methodologies, and involving approximately one million fish captured; one-quarter of which have been assessed for sea lice infestation. The analysis of these data is providing an integrated picture of sea lice infestation patterns on wild salmon populations in B.C., and allowing for a more complete investigation of the factors contributing to spatial and temporal variations in infestations. Preliminary results are shown in Figures 2 & 3.

These data of sea lice on wild pink and chum salmon represents trends coast-wide, with the majority of samples (94% of pink data and 58% of chum data) coming from the Broughton Archipelago. Data clearly show that, besides a peak epizootic event in 2004, of the thousands migrating, 90% of those juvenile pinks sampled each year had no sea louse on them in 8 of the years; in the remaining 6 years 75-90% of the fish had no lice (Fig. 2a). Moreover, for the small percentage of fish having a louse during these 15 years, average number of lice on a single fish was never greater than 2 lice per fish, (Fig. 2b). Similar values and trends as those for pink salmon existed for juvenile chum salmon infestations of sea lice for the same period, coast-wide (Figs. 3a and 3b).

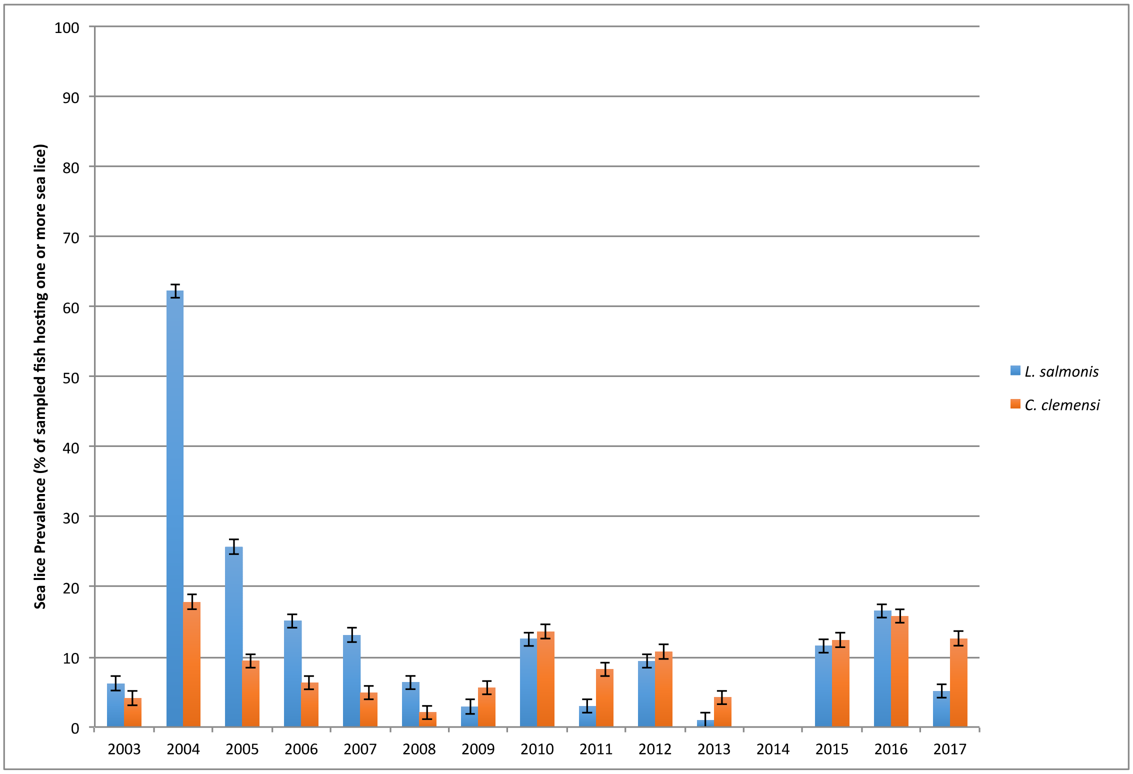

Figure 2a. Prevalence of sea lice (*L. salmonis* and *C. clemensi*) on wild Pink salmon (n = 45,657) sampled by lethal method over a 15-year period, based on data from 337 locations around the B.C. coast. Samples were taken at peak migration periods (March to July, each year). Average weight of pink salmon was 2.3 g.

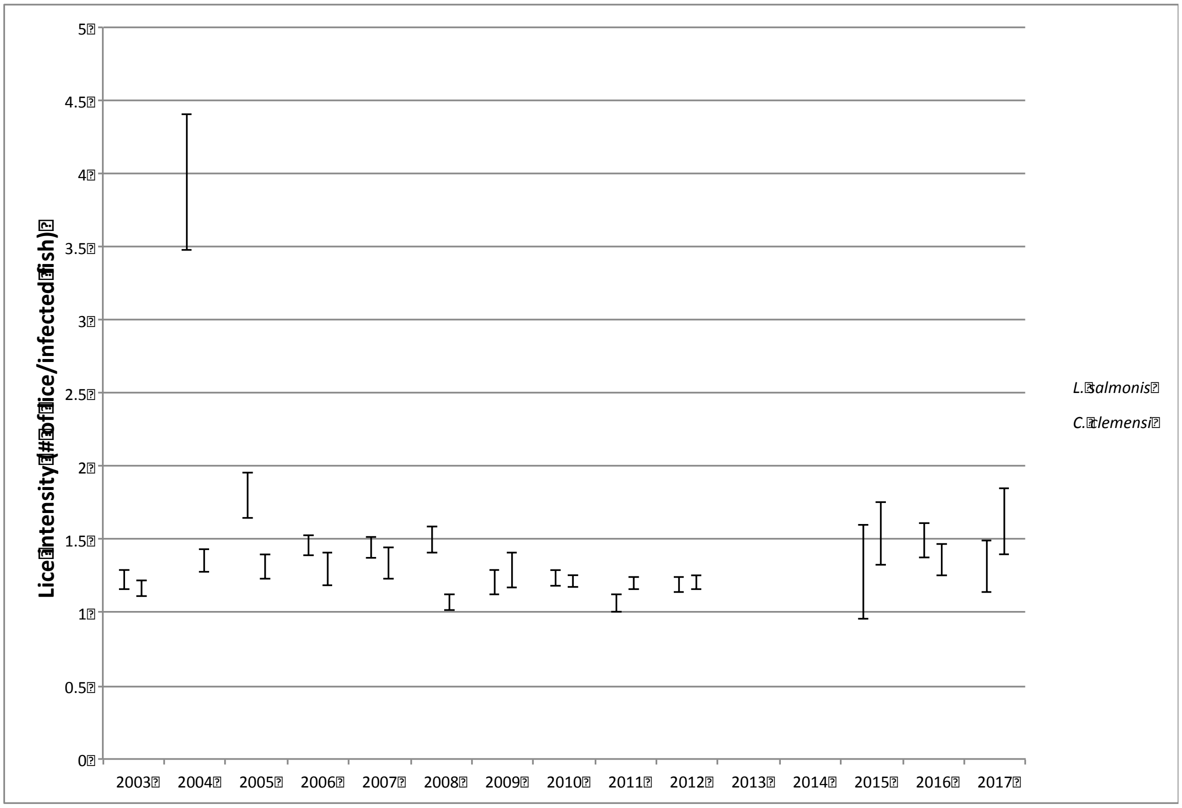

Figure 2b. Intensity of sea lice (*L. salmonis* and *C. clemensi*) on wild Pink salmon (n = 45,657) sampled by lethal method over a 15-year period, based on data from 337 locations around the B.C. coast. Samples were taken at peak migration periods (March to July, each year). Average weight of pink salmon was 2.3 g.

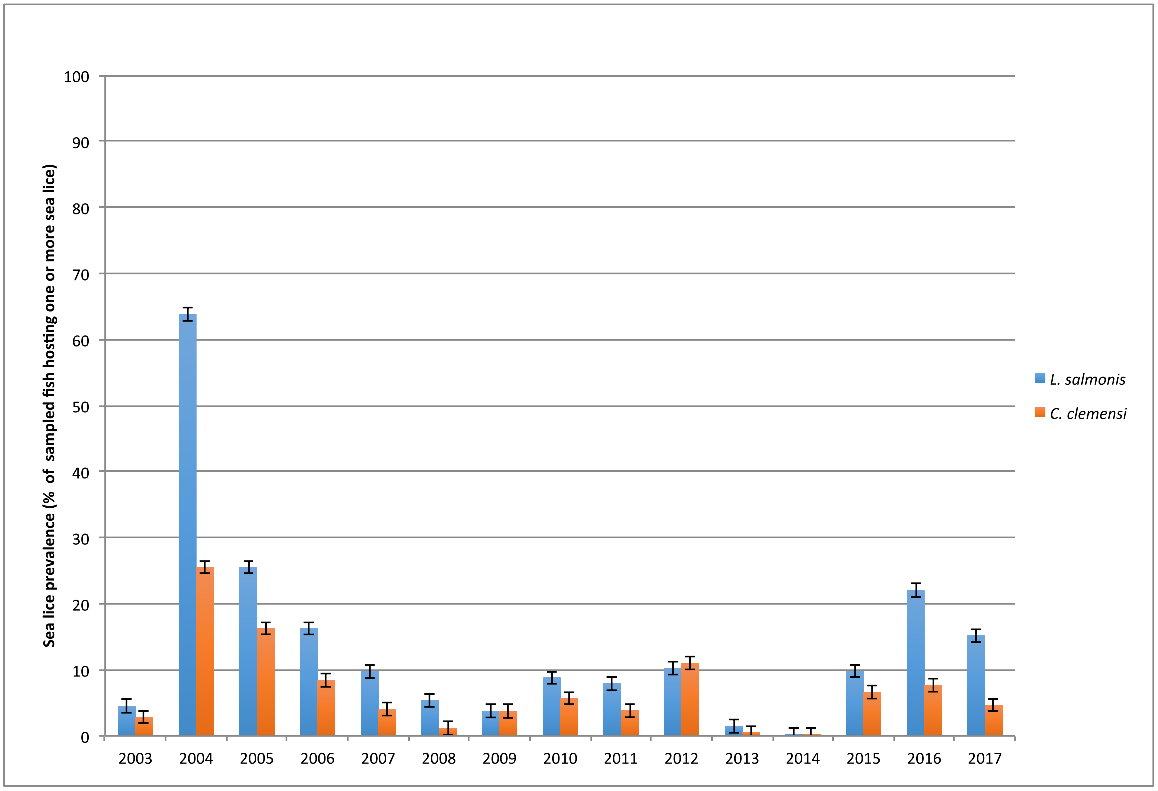

Figure 3a. Prevalence of sea lice (*L. salmonis* and *C. clemensi*) on wild Chum salmon (n = 73,222) sampled by lethal method over a 15-year period, based on data from 337 locations around the B.C. coast. Samples were taken at peak migration periods (March to July, each year). Average weight of chum salmon was 2.5 g.

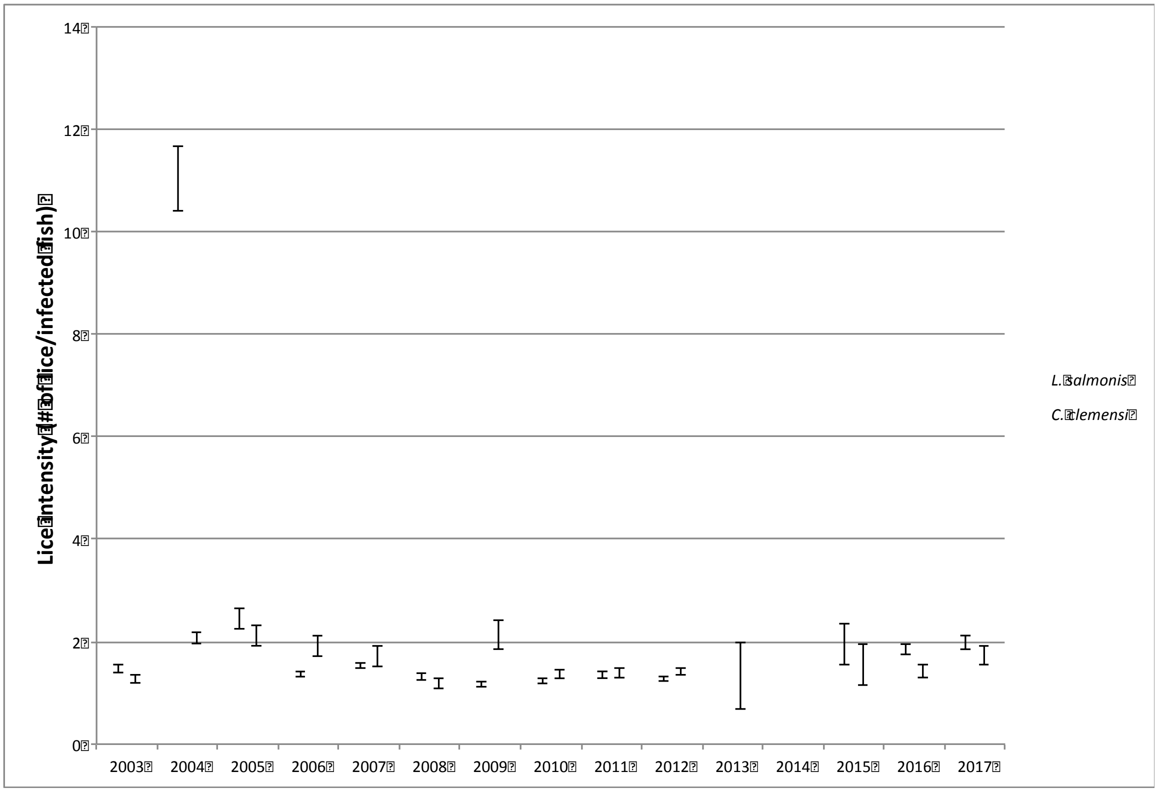

Figure 3b. Intensity of sea lice (*L. salmonis* and *C. clemensi*) on wild Chum salmon (n = 73,222) sampled by lethal method over a 15-year period, based on data from 337 locations around the B.C. coast. Samples were taken at peak migration periods (March to July, each year). Average weight of chum salmon was 2.5 g.

4. Evidence of the risks of escapes to wild salmon

Farmed salmon escapes represent minimal risk of serious harm to wild Pacific salmon and because of the extensive studies that have been conducted on this issue over time, there is certainty around this fact (Cohen, 2012). Between 1905 and 1935, one hundred and seventy times, Atlantic salmon were deliberately released into North American waters where they were not native (MacCrimmon and Gots, 1979). These releases resulted in 13.2 million Atlantic salmon eggs, alevin or fry were released into 52 coastal streams in British Columbia (McKinnel et al, 1995). These releases were by fisheries managers in an attempt to establish spawning populations. Each of these efforts failed (MacCrimmon and Gots, 1979).

After the start of the commercial finfish aquaculture industry in B.C., DFO developed the Atlantic Salmon Watch program, to monitor the presence of Atlantic salmon in marine and freshwater environments in B.C. (DFO, 2018a). The program was first active between 1992 and 2003, and documented adult Atlantic salmon in several river systems on Vancouver Island and the adjacent mainland coast. During 2011 and 2012, the Program was re-established (Andres, 2015), in response to the implementation of the federal Aquaculture Activities Regulations (AAR). The revamped program investigated waterbodies on Vancouver Island that were likely to experience colonization and that adult or juvenile Atlantic salmon had been observed in during previous studies. The revamped ASWP utilized targeted snorkel surveys, lake net traps and stream rotary screw traps and failed to observe a single Atlantic salmon of any life stage. The program then concluded that: ***"…despite the unintended introduction of both adult and juvenile Atlantic salmon into a number of systems in B.C., the establishment of feral populations has not occurred. Further, at present levels and current conditions, the occasional escape of Atlantic salmon from culture can be considered low risk."***

The number of unintentional escapes from B.C. salmon farms has declined substantially in the past decade. For example, from 2001 – 2004, 110,928 farm-raised salmon were reported to have escaped (Noakes, 2011)); from 2011 – 2017, only 75 farm-raised Atlantic salmon were reported to have escaped from marine open net pens (GoC, 2018). Up until the recent (2017) escape of Atlantic salmon from a Washington state aquaculture facility, only one confirmed report of an Atlantic salmon was received by the ASWP between 2012 and 2016 (DFO, 2018a). This adult was captured in a gill net in Queen Charlotte Strait in August of 2014.

In addition to the ASWP, dozens of research programs (non-government organizations, industry, and DFO Science) have been monitoring wild juvenile salmon using beach seine surveys, since 2004. These efforts have mostly focussed on monitoring sea lice infection on wild Pacific salmon. However, it is logical to assume that if data were available on juvenile Atlantic salmon in the wild, through these studies and extensive programs, it would be used to generate peer reviewed research papers. The data simply does not exist. For example, as previously discussed, led by Dr. Crawford Revie of the University of Prince Edward Island, the B.C. Salmon Farmers Association has developed a database of juvenile salmon collected for sea lice infestation analysis, from 2004 to current. Based on data presented at a 2016 BCSFA workshop (BCSFA, 2016), for 2004 – 2014, it is possible to extrapolate for total seine sample size by assuming that 20%, or less, of the fish captured in beach seines over time were kept for further analyses. From this calculation, at least 885,000 individual juvenile salmon have been captured in these beach-seining programs between 2004 and 2014, without a report of a single juvenile Atlantic salmon.

Justice Cohen, in a final report of the Cohen Commission concluded: "I am satisfied that wastes and chemicals discharged at salmon farms, and escapes from salmon farms, are unlikely to have any population level effects on Fraser River sockeye" (Cohen, 2012). Again because all farm-raised salmon in marine open net cages are vaccinated against major diseases of concern (e.g. IHN, BKD), and less than 1% of farm-raised Atlantic salmon die each year of diseases that might transfer to Pacific salmon, disease from escaped farmed Atlantic salmon is unlikely to have any population level effect on wild Pacific salmon (Marty, 2015).

Peer-Reviewed Processes to Assess Risk & Their Outcomes

Since the mid- 1980's, there have been at least six formal reviews of the salmon farming industry's interactions with wild salmon in B.C., assessing the perceived risk by reviewing the state of knowledge:

1. Gillespie Inquiry 1986
2. Aquaculture Industry Advisory Council 1993
3. Salmon Aquaculture Review 1997
4. Special Legislative Committee on Sustainable Aquaculture 2007
5. B.C. Pacific Salmon Forum 2009, and
6. Cohen Commission 2012.

These reviews have involved hundreds, if not thousands, of people, and cost millions of dollars. Meanwhile, from review to review, over time, B.C.'s salmon farming industry has been quickly evolving with research and innovations in fish health management, infrastructure and production technologies becoming more economically and environmentally sustainable (BCSFA, 2017; MNP, 2017). Over time, the scope of the recommendations has become more focussed, as the industry and regulators have improved management practices and narrowed the level of uncertainty that salmon farming does not pose a greater than minimal risk of serious harm to wild salmon populations.

The most recent, and significant, review involving the B.C. salmon farming industry has been the Cohen Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River. The Inquiry, through 139 days of hearings, nearly 200 witnesses and thousands of exhibits and hundreds of public commissions, investigated, in great detail, all of the variables that could be attributing to impacts upon Fraser River Sockeye in an effort to identify the cause and make recommendations to support positive change. Potential causes that were investigated included: predation, infectious disease, contaminants, climate change, stressors in the freshwater environment (logging, agriculture, gravel removal, pup and paper mills, metal mining, municipal wastewater, and other development related impacts on habitat), and stressors in the marine environment (harmful algal blooms, salmon farms, sea lice, variations in marine productivity, and competition factors).

Justice Cohen determined that there was no "smoking gun" that could be attributable as a single factor to the population's decline. In his final report, he wrote that: *"The idea that a single event or stressor is responsible for the 1992-2009 decline in Fraser River sockeye is appealing but improbable"* and *"I am also satisfied that marine conditions in both the Strait of Georgia and Queen Charlotte Sound in 2007 were likely to be the primary factors responsible for the poor returns in 2009." (Final Report (Vol 3), page 59).* With respect to salmon aquaculture, Justice Cohen stated *"Data presented during this Inquiry <u>did not</u> show that salmon farms were having a significant negative impact on Fraser River sockeye. However, as noted above, the statistical power of the database (containing fish health data from 2004 to 2010) was too low to rule out significant negative impact. I accept the evidence of Dr. Korman and Dr. Dill that scientists need* *another 10 years of regulatory data (until at least mid-2020) before they can more confidently identify any relationships that may exist." (Final Report (Vol 3), page 24).*

Ultimately, the Inquiry cost $37 million and resulted in 75 recommendations to the federal government in 2012. Recommendations span a wide range of fisheries management areas. Thirteen recommendations were focussed on aquaculture management in British Columbia. DFO reported in 2017 that 11 of the 13 recommendations had been acted upon – these include:

- new fish farm siting guidelines developed in collaboration with the Province of B.C., First Nations and stakeholders;
- the collection of fish health data from salmon farm operators; and the publication of fish health data on DFO's website and through the federal Open Data portal. DFO staff are working on improving the accessibility and timelines for fish health data availability. The salmon farming industry is supportive of this initiative.
- new scientific studies to fill knowledge gaps, inform standards and operation requirements and guide practices at hatcheries, as well as adjust requirements on where salmon farms can be located. No new licenses are being permitted in the Discovery Islands until DFO is satisfied that there is not more than minimal risk of serious harm to Fraser River Sockeye (DFO, 2018b).

DFO's action on the Commission's recommendations has been further supported through recent new investments including $197 million over five years for ocean and freshwater science, $1.5 billion over 5 years for the Oceans Protection Plan (OPP) and $250 million over five years, plus $62.2 million ongoing for renewal and expansion of the integrated commercial fisheries initiatives, including the Pacific Integrated Commercial Fisheries Initiative (PCFI).

One of the remaining recommendations (allowing the licensing of salmon farm facilities in the Discovery Islands) has a decision date of 2020 and will be based on the results from scientific studies that are currently underway, including research investigating the impacts of pathogens from fish farms on migrating wild Pacific salmon (DFO, 2017). As referenced previously, the results of the first risk assessment have indicated that the risk of IHNv from farm-raised salmon in the Discovery Islands to wild salmon is minimal.

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Appendix 11 – Council Member View of the Duty of the Minister of Fisheries and Oceans to Apply the Precautionary Principle

Inclusion does not imply endorsement of council

Appendix 11 – Council Member View of the Duty of the Minister of Fisheries and Oceans to Apply the Precautionary Principle

The following appendix has been prepared by Tony Allard and is provided for information and its inclusion does not imply endorsement by the council.

There are constitutional, legislative, policy and international obligations that require the Minister to apply the precautionary principle. The precautionary principle does more than forbid decision makers from using scientific uncertainty as an excuse for regulatory inaction. It requires decision makers to err on the side of caution by anticipating harm and taking protective measures when there is environmental risk, even if there is scientific uncertainty.

The federal government has a constitutional obligation to protect fisheries and oceans. Section 91(12) of the *Constitution Act, 1867* gives the federal government jurisdiction over the "Sea Coast and Inland Fisheries".

Both the *Fisheries Act*, RSC 1985, c F-14 and the *Oceans Act, SC 1996, c 31* flow from this constitutional mandate to protect fisheries and oceans. The *Oceans Act* expressly requires the Minister to apply the precautionary principle to all matters in his jurisdiction.

The history of the *Oceans Act* is important to understanding its legislative intent. By the early 1990s, the cod fishery on Canada's Atlantic coast had collapsed. The *Oceans Act* was passed in 1996 to ensure that such a catastrophe never occurred again in Canada. The *Oceans Act* extended Canada's jurisdiction over marine waters and required an ecosystem approach to the management of the marine environment based on the precautionary principle.

Sections 29 and 30 of the *Oceans Act* expressly require the Minister to apply the precautionary principle.

Moreover, in the Prime Minister's Mandate Letter to the Minister, the Prime Minister expressly requires the Minister to "[u]se scientific evidence and the precautionary principle, and take into account climate change, when making decisions affecting fish stocks and ecosystem management".

In *The Uncertain Future of the Fraser River Sockeye* (the "Cohen Commission"), Mr. Justice Cohen came to similar conclusion. Mr. Justice Cohen observed that the Federal Court in *Environmental Defence Canada v. Canada (Fisheries and Oceans)*, 2009 FC 878 said that Canada had ratified the *United Nations Convention on the Conservation of Biological Diversity (the Convention)* and, since the precautionary principle was a main component of that convention, Canada had committed to apply the precautionary principle.

Canada has also committed to the precautionary principle in several pieces of federal legislation, including the *Oceans Act,* the *Canadian Environmental Protection Act*, 1999, SC 1999, c 33, and the *Canadian Environmental Assessment Act, 2012*, SC 2012, c 19, s 52.

Government Guidance on Applying the Precautionary Principle

Canada's Policy for the Conservation of Wild Salmon expressly requires the precautionary principle to be applied with respect to the conservation of wild salmon.

A Canadian Perspective on the Precautionary Approach/Principle further confirms "[t]he *Oceans Act* requires the government to promote a wide application of the precautionary approach to the conservation, management and exploitation of marine resources."

Canada's Policy for the Conservation of Wild Salmon expressly requires the precautionary principle to be applied with respect to the conservation of wild salmon and expressly relies on the federal government's *A Framework for the Application of Precaution in Science-based Decision Making About Risk*. That framework articulates 10 principles for applying the precautionary principle: five general principles of application and five principles for precautionary measures.

Case Law on the Application of the Precautionary Principle to Aquaculture

Both *Brighton v. Nova Scotia*, 2002 NSSC 160, and *Morton v. Canada 2015 FC 575 (*"*Morton 2015*") confirm that the Minister is required to apply the precautionary principle to the regulation of fish farms.

In *Morton 2015,* Mr. Justice Rennie found that the risk associated with PRV, and the scientific uncertainty about that risk, triggered the application of the precautionary principle and specifically cited the seminal Supreme Court of Canada decision in *114957 Canada Ltée (Spray-Tech, Société d'arrosage) v. Hudson (Ville)*:

> …although there is a healthy debate between respected scientists on the issue, the evidence, suggests that the disease agent (PRV) may be harmful to the protection and conservation of fish, and therefore a "lack of full scientific certainty should not be used a reason for postponing measures to prevent environmental degradation": *Spraytech* at para 31.

Mr. Justice Rennie's decision in *Morton* is particularly important in advancing our understanding of the precautionary principle as it is applied in the administrative law context: when the standard of review is reasonableness, then the decision maker's range of reasonable decisions is limited to those that err on the side of caution.

Mr. Justice Rennie confirmed that the precautionary principle includes a positive duty to err on the side of caution and regulatory action that embodies the precautionary principle is "designed to anticipate and prevent harm even in the absence of scientific certainty that such harm will in fact occur".

This interpretation is consistent with the *Oceans Act*'s description of the precautionary principle: "the precautionary approach, that is, erring on the side of caution". Mr. Justice Rennie's interpretation also sits squarely with the classic statement of the precautionary principle by the Supreme Court of Canada in the *Spray-Tech* decision, but it shifts the emphasis away from scientific uncertainty, where the discussion is often focused, and places it back on anticipation and prevention of environmental harm:

> In order to achieve sustainable development, policies must be based on the precautionary principle. <u>Environmental measures must anticipate, prevent and attack the causes of environmental degradation.</u> Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (emphasis added).

The precautionary principle does more than forbid decision makers from using scientific uncertainty as an excuse for regulatory inaction. It requires decision makers to err on the side of caution by anticipating harm and taking protective measures when there is environmental risk even if there is scientific uncertainty. The precautionary principle's objective is to protect the environment from the ecological risks of commerce, not to sanction commerce that poses ecological risks beyond what society's values will tolerate.

The federal government has a constitutional obligation to protect fisheries and oceans. Section 91(12) of the *Constitution Act, 1867* gives the federal government jurisdiction over the "Sea Coast and Inland Fisheries". As far back as the 1882 case of *The Queen v. Robertson*, the Supreme Court of Canada held that the jurisdiction conferred by s. 91(12) requires the federal government to carry out the public-interest mandate of protecting fisheries:

> …the general jurisdiction over the fisheries is secured to the parliament of the Dominion, whereby they are enabled to pass all laws necessary for their preservation and protection, this being the only matter of general public interest in which the whole Dominion is interested in connection with river fisheries in fresh water, non-tidal rivers or streams…[129]

129 *The Queen v. Robertson* (1882), 6 SCR 52 at 120–124.

A long line of case law has followed and applied this reasoning.[130] In *Morton v. British Columbia*, (2009), BCSC 136 ("*Morton 2009*") Mr. Justice Hinkson, following *The Queen v. Robertson,* said:

Given the specific enumeration of the management and protection of the fisheries in s. 91(12) of the *Constitution Act, 1867*, the national resource of the fisheries in not a matter that should or can be left to a level of government other than Parliament.[131]

Both the *Fisheries Act*, RSC 1985, c F-14 and the *Oceans Act, SC 1996, c 31* flow from this constitutional mandate to protect fisheries and oceans. The *Oceans Act* expressly requires the Minister to apply the precautionary principle to all matters in his jurisdiction.

The history of the *Oceans Act* is important to understanding its legislative intent. By the early 1990s, the cod fishery on Canada's Atlantic coast had collapsed. The *Oceans Act* was passed in 1996 to ensure that such a catastrophe never occurred again in Canada.[132] The *Oceans Act* extended Canada's jurisdiction over marine waters and required an ecosystem approach to the management of the marine environment based on the precautionary principle.

Sections 29 and 30 of the *Oceans Act* expressly require the Minister to apply the precautionary principle. Section 29 of the *Oceans Act* says:

> *Development and implementation of strategy*
>
> 29 The Minister, in collaboration with other ministers, boards and agencies of the Government of Canada, with provincial and territorial governments and with affected aboriginal organizations, coastal communities and other persons and bodies, including those bodies established under land claims agreements, <u>shall lead and facilitate the development and implementation of a national strategy for the management of estuarine, coastal and marine ecosystems in waters that form part of Canada</u> or in which Canada has sovereign rights under international law (emphasis added).

Section 30 describes the principles the Minister must use in implementing the strategy:

> *Principles of strategy*
>
> 30 The national strategy will be based on the principles of

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130 See for example, *Reference re: British North America Act, 1867, s. 108*, [1898] JCJ No, 1, [1898] A.C. 700; *Gulf Trollers Assn. v. Canada (Minister of Fisheries & Oceans)*, 32 D.L.R. (4th) 737, leave to appeal refused *Gulf Trollers Assn. v. Canada (Minister of Fisheries & Oceans)*, 77 N.R. 157; and *Ward v. Canada (Attorney General),* 2002 SCC 17.

131 *Morton v. British Columbia*, 2009 BCSC 136, at para 193.

132 *House of Commons Debates, 35th Parl, 1st Sess, No.231 (26 September 1995) at 14861-14864; 14872-14873 (Hon. Brian Tobin). House of Commons Debates, 35th Parl, 2nd Sess, No.158 (17 April 1996) (Hon. Fred Mifflin).*

> (a) sustainable development, that is, development that meets the needs of the present without compromising the ability of future generations to meet their own needs;
>
> (b) the integrated management of activities in estuaries, coastal waters and marine waters that form part of Canada or in which Canada has sovereign rights under international law; and
>
> **(**c) <u>the precautionary approach, that is, erring on the side of caution</u> (emphasis added).

Section 30(c) is important. Although the precautionary principle is espoused as part of international and environmental law, seldom is its use expressly required by legislation.[133] Generally speaking, the application of the precautionary principle is a permissive, not mandatory, rule. It may be, and sometimes is, used by courts to support a finding that a decision is unreasonable or that a statutory interpretation is not correct, but it is usually not determinative on its own without express incorporation into statute. For the precautionary principle to be a required consideration or to be determinative when challenging a tribunal or court decision, it must be expressly incorporated into the governing legislation.[134] Section 30(c) is that express incorporation that creates a positive duty for the Minister to apply the precautionary principle.

Further, s. 40 states that:

> The powers, ***duties*** and functions of the Minister extend to and include all matters over which Parliament has jurisdiction, not

133 *Toews v. British Columbia (Ministry of Environment)* 2015 BCEA No. 25 at para 225 ("the phrases 'precautionary principle' and 'precautionary approach' are used in international treaties and some Canadian environmental statutes.").

134 *Toews* at para 227. The British Columbia Environmental Appeal Board found that the precautionary principle did not apply to the *Environmental Management Act* because it was not referenced in the statute. The board said that "if the Legislature had intended to incorporate the precautionary principle into the legislation it would have done so." See also *Western Canada Wilderness Committee v. British Columbia (Ministry of Forests, South Island Forest District)*, 2003 BCCA 403. (The appeal was denied because the precautionary principle was not incorporated into the relevant legislation and therefore did not need to be given full effect by the Manager in her decision.) *Tsawwassen Residents against Higher Voltage Overhead Lines Society v. British Columbia (Utilities Commission)*, 2007 BCCA 211. (The Court of Appeal considered whether the precautionary principle is a "norm of customary international law, part of the common law of Canada and a mandatory rule of construction to be applied to domestic legislation". The Court declined to decide the matter as it was beyond the scope of the appeal but did say in obiter than such a finding would require existing case law to be overturned.). *Fort Nelson First Nation v. British Columbia (Ministry of Environment)* 2015 BCEA No. 18 at para 44. (The British Columbia Environmental Appeal Board found that "the precautionary principle is not mentioned in the *Water Act* and there is no indication that the Legislature intended this principle to apply to water licensing decisions.") *Cowichan Valley Regional District v. British Columbia (Ministry of Water, Land and Air Protection)* 2003 BCEA No.1 at para 55. (The British Columbia Environmental Appeal Board found that "there is no requirement to presume that the legislature intended the [legislation] to reflect the precautionary principle, and that there is no clear indication of such intention in the relevant statutory provisions, the Panel is not required to apply or consider the precautionary principle…").

> assigned by law to any other department, board or agency of the Government of Canada, relating to the policies and programs of the Government of Canada respecting oceans (emphasis added).

Sections 29, 30, and 40 create a positive duty for the Minister to apply the precautionary principle[135] to all matters under his jurisdiction.

Moreover, in the Prime Minister's Mandate Letter to the Minister, the Prime Minister expressly requires the Minister to "[u]se scientific evidence and the precautionary principle, and take into account climate change, when making decisions affecting fish stocks and ecosystem management".[136]

In *The Uncertain Future of the Fraser River Sockeye* (the "Cohen Commission"), Mr. Justice Cohen came to a similar conclusion. Mr. Justice Cohen observed that the Federal Court in *Environmental Defence Canada v. Canada (Fisheries and Oceans)*, 2009 FC 878 said that Canada had ratified the *United Nations Convention on the Conservation of Biological Diversity (the Convention)* and, since the precautionary principle was a main component of that convention, Canada had committed to apply the precautionary principle.[137] Mr. Justice Cohen also observed that Canada had become a party to other international agreements which contained the precautionary principle and that Canada had committed to the precautionary principle in several pieces of federal legislation, including the *Oceans Act,* the *Canadian Environmental Protection Act*, 1999, SC 1999, c 33, and the *Canadian Environmental Assessment Act, 2012*, SC 2012, c 19, s 52.[138] Mr. Justice Cohen also observed that several federal policies required the application of the precautionary principle:

> Canada has also incorporated the precautionary principle (or precautionary approach) into various relevant policies, action plans, and strategies, including the Wild Salmon Policy, the 2002 Aquaculture Policy Framework, DFO's *2005–10 Strategic Plan: Our Waters, Our Future*, the Federal Sustainable Development Strategy, Canada's Framework for Science and Technology

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135 Although the "precautionary approach" is used in the *Oceans Act,* "precautionary principle" is more commonly used by the courts, and is used in the case law interchangeably with "precautionary approach". For consistency with the case law quoted throughout this document, "precautionary principle" is used unless quoting material containing the phrase "precautionary approach."

136 Mandate Letter, bullet 4.

137 See *Environmental Defence Canada v. Canada (Fisheries and Oceans),* 2009 FC 878 at para. 34. See also Cohen Commission, Volume 1, at page 36.

138 Cohen Commission, Volume 1, page 37.

> Advice, the 2005 Oceans Action Plan, and the Sustainable Fisheries Framework, among others.[139]

Government Guidance on Applying the Precautionary Principle

Canada's Policy for the Conservation of Wild Salmon expressly requires the precautionary principle to be applied with respect to the conservation of wild salmon:

> Precautionary approaches are now widely applied in fisheries management and the protection of marine ecosystems. The approach identifies important considerations for management: acknowledgement of uncertainty in information and future impacts and the need for decision making in the absence of full information. It implies a reversal in the burden of proof and the need for longer term outlooks in conservation of resources.
>
> The application of precaution in the WSP will follow the guidance provided to Federal Departments by the Privy Council Office publication13 entitled "A Framework for the Application of Precaution in Science-based Decision Making About Risk." (Canada, Privy Council Office 2003). That Framework includes five principles of precaution:
>
> - The application of the precautionary approach is a legitimate and distinctive decision making approach within a risk management framework.
> - Decisions should be guided by society's chosen level of risk.
> - Application of the precautionary approach should be based on sound scientific information.
> - Mechanisms for re-evaluation and transparency should exist.
> - A high degree of transparency, clear accountability, and meaningful public involvement are appropriate.
>
> The WSP will adhere to the use of precaution and be consistent with the Privy Council Office framework and FAO14 (1995, paragraph 6 (a-h)).[140]

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[139] Cohen Commission, Volume 1, page 37 (footnotes omitted).

[140] *Canada's Policy for the Conservation of Wild Salmon,* page 15, available here: http://waves-vagues.dfo-mpo.gc.ca/Library/315577.pdf.

When implementing the precautionary principle, the Minister should also be guided by documents such as *Canada's Oceans Strategy* and *A Canadian Perspective on the Precautionary Approach/Principle*, among others, but should be especially guided by *A Framework for the Application of Precaution in Science-based Decision Making About Risk* (the "*Framework*") as *Canada's Policy for the Conservation of Wild Salmon* expressly relies on it.

Canada's Oceans Strategy provides guidance on how the precautionary principle should be employed:

> Canada holds that conservation, based on an **ecosystem approach**, is of fundamental importance to maintaining biological diversity and productivity in the marine environment;
>
> Canada promotes the wide application of the **precautionary approach** to the conservation, management and exploitation of marine resources in order to protect these resources and preserve the marine environment; (emphasis in the original).[141]
>
> The **precautionary approach**, defined in the *Oceans Act* as "erring on the side of caution," is a key principle to be applied in the management of ocean activities. Under the *Strategy*, the Government of Canada is re-affirming its commitment to promoting the <u>wide application of the precautionary approach to the conservation, management and exploitation of marine resources in order to protect these resources and preserve the marine environment</u> (bolding in original; underlining added).[142]

A *Canadian Perspective on the Precautionary Approach/Principle* says that:

> Sound scientific information and its evaluation must be the basis for applying the precautionary approach, particularly with regard to (i) the decision to act or not to act (i.e., to implement precautionary measures or not), and (ii) the measures taken once a decision is made.
>
> A valid and reasonable scientific information base underpins the application of the precautionary approach.
>
> Before the precautionary approach can be applied, scientific data relevant to the risk must be evaluated through a sound, credible, transparent and inclusive mechanism leading to a

141 "Canada's Oceans Strategy" (2002) 3–4, online: http://waves-vagues.dfo-mpo.gc.ca/Library/264675.pdf.
142 *Ibid* at 11.

> conclusion that expresses the possibility of occurrence of harm and the magnitude of that harm (including the extent of possible damage, persistency, reversibility and delayed effect).[143]

A Canadian Perspective on the Precautionary Approach/Principle further confirms that "[t]he *Oceans Act* requires the government to promote a wide application of the precautionary approach to the conservation, management and exploitation of marine resources."[144]

The federal government's *Framework* articulates 10 principles for applying the precautionary principle: five general principles of application and five principles for precautionary measures. The introduction to those 10 principles says in part:

> The application of "precaution", "the precautionary principle" or "the precautionary approach" recognizes that the absence of full scientific certainty shall not be used as a reason for postponing decisions where there is a risk of serious or irreversible harm.
>
> The application of precaution is distinctive within science-based risk management and is characterized by three basic tenets: the need for a decision, a risk of serious or irreversible harm and a lack of full scientific certainty.[145]

The *Framework* recognizes that the precautionary principle is a legitimate risk management tool, and that sound science should inform decisions on how to act and the precautionary measures to be taken. Importantly, the first principle recognizes that "[u]ltimately it [precaution] is guided by judgment, based on values and priorities".[146] Accordingly, the second principle confirms that the level of protection must be aligned with society's values so that "decisions [are] guided by society's chosen level of protection against risk".[147]

The *Framework* requires further scientific evaluation once decisions are made to both measure their efficacy and to ensure a transparent consultation process on those measures. Indeed, the *Framework* expressly recognizes the need for a "high degree of transparency" when the

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143 *"A Canadian Perspective on the Precautionary Approach/Principle"*, available here: http://www.ibrarian.net/navon/paper/A_Canadian_Perspective_on_the_Precautionary_Appro.pdf?paperid=990195.

144 *Ibid*.

145 "A Framework for the Application of Precaution in Science-based Decision Making About Risk." (Canada, Privy Council Office 2003), principle 4.10, page 13, available here: http://www.pco-bcp.gc.ca/docs/information/publications/precaution/Precaution-eng.pdf, page 2.

146 *Ibid,* page 6.

147 *Ibid,* page 6.

precautionary principle is engaged.[148] Further, precautionary measures should be proportionate to the level of risk and evolve as the science on the issue evolves.[149]

Since the *Framework* provides a series principles a decision-maker must follow to protect the environment, it is not surprising that the *Framework* makes it expressly clear that any impact on the assessment of trade occurs only after the decision-maker has determined the level of protection is consistent with society's values. Accordingly, the *Framework's* last principle makes it clear that the impact on trade is to be considered only after the decision to apply precautionary measures has been made:

> When making a choice among different types of measures that would provide a similar level of response to the potential for harm, there should be an endeavour to select measures that would be "least trade-restrictive".[150]

First, a level of protection is chosen so that it is aligned with society's values. Second, options for protective measures that meet that level of protection are identified. Third, and only after the first two steps, the impacts on trade are assessed and protective measures that may have a lesser effect on trade may only be chosen if they maintain an equal level of protection.[151] The decision-maker cannot decrease the level of protection to increase trade. Rather, once society's chosen level of protection has been determined, the decision-maker can only choose between protective measures that maintain that level of protection. If multiple options for precautionary measures are available that provide the same level of protection, only then can the decision-maker choose the least trade-restrictive option.

The decision-making process required by the *Framework* is consistent with the federal government's mandate to protect and oceans and fisheries and the fundamental purpose of the precautionary principle: "The precautionary principle is a tool for environmental risk management aimed at preventing environmental problems rather than dealing with their consequences."[152] Indeed, put another way, the precautionary principle's objective is to protect the environment from the ecological risks of commerce, not to sanction commerce that poses ecological risks beyond what society's values will tolerate.

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148 *Ibid,* page 9.

149 *Ibid,* pages 10 and 11. See also "Canada's Oceans Strategy" (2002) 3–4, online: http://waves-vagues.dfo-mpo.gc.ca/Library/264675.pdf.

150 *Ibid,* page 13.

151 *Ibid,* page 13.

152 Pierre Cloutier de Repentigny "*Precaution, Sub-Delegation and Aquaculture Regulation: Morton v. Canada (Fisheries and Oceans)*" (2015) 28:1 J Envtl L & Prac 127 at 134; Marco Martuzzi & Joel A Tickner (eds.), *Precautionary Principle: Protecting Public Health, the Environment and the Future of Our Children* (Copenhagen: World Health Organization (Europe), 2004) at 21–22; Stephanie Joan Mead, "*The Precautionary Principle: A Discussion of the Principle's Meaning and Status in an Attempt to Further Define and Understand the Principle*" (2004) 8 NZ J Envtl L 137 at 146, 151; and Arie Trouwborst, *Evolution and Status of the Precautionary Principle in International Law* (The Hague: Kluwer Law International, 2002) at 10–11.

Case Law on the Application of the Precautionary Principle to Aquaculture

In *114957 Canada Ltée (Spray-Tech, Société d'arrosage) v. Hudson (Ville)*, the Supreme Court of Canada defined the precautionary principle as follows:

> In order to achieve sustainable development, policies must be based on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.[153]

Both *Brighton v. Nova Scotia*, 2002 NSSC 160, and *Morton v. Canada 2015 FC 575 (*"*Morton 2015*") confirm that the Minister is required to apply the precautionary principle to the regulation of fish farms.[154]

In *Morton 2015,* Mr. Justice Rennie found that the risk associated with PRV, and the scientific uncertainty about that risk, triggered the application of the precautionary principle and specifically cited the *Spray-Tech* decision:

> …although there is a healthy debate between respected scientists on the issue, the evidence, suggests that the disease agent (PRV) may be harmful to the protection and conservation of fish, and therefore a "lack of full scientific certainty should not be used a reason for postponing measures to prevent environmental degradation": *Spraytech* at para 31.[155]

Mr. Justice Rennie's decision in *Morton 2015* is particularly important in advancing our understanding of the precautionary principle as it is applied in the administrative law context: when the standard of review is reasonableness, then the decision maker's range of reasonable decisions is limited to those that err on the side of caution. Mr. Cloutier de Repentigny[156] explains:

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153 *114957 Canada Ltée (Spray-Tech, Société d'arrosage) v. Hudson (Ville),* [2001] 2 SCR 241 at para 31, quoting para 7 of the *Bergen Ministerial Declaration on Sustainable Development* (1990).

154 *Brighton v. Nova Scotia*, 2002 NSSC 160 at para 30. See also *Morton v. Canada (Fisheries and Oceans),* 2015 FC 575 at paras 40, 43, 44, 46, 96–99.

155 *Morton 2015* at para 45.

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DFO and Marine Harvest claimed that since there was no evidence of a clear link between PRV and HSMI, aquaculture licences could permit, subject to their conditions, the transfer of fish with PRV. The Court rejected this argument as running contrary to the precautionary principle. The evidence showed that there was at least a risk that PRV and HSMI were linked, and thus that PRV may be harmful to fish. In the words of Rennie J. "there is a body of credible scientific study, conducted by respected scientists in different countries, establishing a causal relationship between PRV and HSMI." In the absence of scientific certainty, caution dictated that transferring fish with PRV should not be allowed in order to protect and conserve fish.

Justice Rennie also used the precautionary principle to interpret the *Regulations*, along with the ‘‘golden rule" of statutory interpretation. While reasonableness means that the court should be deferential to the Minister's interpretation of legislation related to her expertise, the lack of decision-making record and reasons makes deference, as noted above, difficult to operationalize in this case. Additionally, it seems that regardless of the move towards a broader application of the reasonableness standard, courts are still expected to use traditional statutory interpretation tools to determine the range of acceptable outcomes. In *Morton*, the strong language of paragraph 56(b) of the *Regulations*, the precautionary principle, and the resource conservation purpose of the *Fisheries Act* all pointed towards a strong prohibition of transfers of fish with a disease that *may* be harmful. Furthermore, Rennie J. found that ‘‘subsection 56(b) of the *FGRs*, properly construed, embodies the precautionary principle" as the provision covers any disease or disease agent that may be harmful, language hinting that scientific certainty is not required. <u>From this interpretation, the judge found that only licence conditions that would reflect the strong regulatory obligations against potentially harmful fish transfer could be reasonable</u>. <u>A decision to issue a licence is thus unreasonable if it permits a risk of contamination</u> (italics in original; underlining added).[157]

[157] Pierre Cloutier de Repentigny (2015) *op. cit.* at note **Error! Bookmark not defined.**, at 127–153, 135–136. Footnotes omitted, but see *Morton* at paras 44–46, 57, 97–98.

Mr. Cloutier de Repentigny's elucidation of Mr. Rennie's decision is important: where a decision-maker, like the Minister, must apply the precautionary principle, the range of reasonable decisions the decision-maker can reach is limited to those that err on the side of caution. This is an important clarification of the precautionary principle.

In *Blaney et al v. British Columbia (The Minister of Agriculture Food and Fisheries) et al*, 2005 BCSC 283, in a case that was about finfish aquaculture, the B.C. Minister of Agriculture argued that "the precautionary principle does not require government action, but simply says that lack of scientific knowledge is not an excuse to fail to take action."[158] The court in *Blaney* did not have to address this argument directly.

However, what Mr. Justice Rennie in *Morton 2015* made clear is that the argument is not valid. Mr. Justice Rennie confirmed that the precautionary principle includes a positive duty to err on the side of caution[159] and regulatory action that embodies the precautionary principle is "designed to anticipate and prevent harm even in the absence of scientific certainty that such harm will in fact occur".[160] This interpretation is consistent with the *Oceans Act*'s description of the precautionary principle: "the precautionary approach, that is, erring on the side of caution".[161] Mr. Justice Rennie's interpretation also sits squarely with the classic statement of the precautionary principle by the Supreme Court of Canada in the *Spray-Tech* decision, but it shifts the emphasis away from scientific uncertainty, where the discussion is often focused, and placed it back on anticipation and prevention of environmental harm:

> In order to achieve sustainable development, policies must be based on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (emphasis added).[162]

The precautionary principle does more than forbid decision makers from using scientific uncertainty as an excuse for regulatory inaction. It requires decision makers to err on the side

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158 *Blaney et al v. British Columbia (The Minister of Agriculture Food and Fisheries) et al*, 2005 BCSC 283 at. para. 41. In that case the Supreme Court of British Columbia found that the precautionary principle did not require the government to halt all action that constituted some environmental risk. This is correct, and still true, today. The precautionary principle does not require the government to necessarily halt action; it requires it to assess risk, and take protective measures that are aligned with what society has deemed an acceptable level of risk. See "A Framework for the Application of Precaution in Science-based Decision Making About Risk." (Canada, Privy Council Office 2003), principle 4.2, page 8, available here: http://www.pco-bcp.gc.ca/docs/information/publications/precaution/Precaution-eng.pdf.

159 *Morton 2015,* para. 46.

160 *Morton 2015,* para. 99.

161 *Ocean Act, s. 30(c).*

162 See note **Error! Bookmark not defined.**.

of caution by anticipating harm and taking protective measures when there is environmental risk even if there is scientific uncertainty.