BC PACIFIC SALMON FORUM

FINAL REPORT & RECOMMENDATIONS

TO THE GOVERNMENT OF BRITISH COLUMBIA

JANUARY 2009

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SUBMISSION LETTER

Dear Premier Campbell:

Thriving wild salmon are vital to British Columbia's cultural and economic fabric. Their abundant presence tells us that our ocean and freshwater ecosystems are healthy.

Today, in many watersheds across the Province, wild salmon face unprecedented threats to their survival and many stocks are declining. Worse yet, these threats are growing because of changes in climate affecting both ocean and freshwater habitat.

Over the past generation, while many wild salmon stocks faced increased jeopardy, salmon farming has been growing. The salmon farming industry has joined the wild salmon fishery as an important economic force sustaining many coastal communities in BC, as well as in providing quality seafood.

Today the public policy challenge is to find ways to ensure that this newer industry can prosper without harming wild salmon or long-established activities that depend upon them.

In December 2004, you appointed us - six independent citizens, under the leadership of Honourable John Fraser - to study these issues and provide policy recommendations to the Province. You asked us how the Province could: protect and enhance the viability of wild salmon and their economic, social and environmental benefits to British Columbians; increase public confidence in fisheries management generally, and aquaculture in particular, in the marine environment; and enhance the economic, social and environmental sustainability of aquaculture for all coastal communities.

For the past four years our work has been informed by existing science, new research funded by the Province, and consultation with a wide range of interests.

That work has led us to propose that British Columbia adopt a transformative management approach, not just to salmon but to the management of all resource industries operating in our watersheds and marine systems. We believe that this approach will significantly reduce long-term threats to sustainable salmon populations. We also believe that it will protect the Province's watersheds and marine areas and even support their rehabilitation. The required policy changes are compatible with recent provincial initiatives to protect the Province's waters and to reduce carbon emissions. Having said that, we appreciate that this shift will require major attitudinal and institutional changes - not just in government but in all users and across our society.

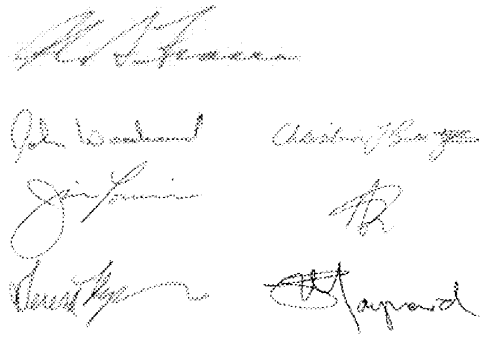
One of the most important findings from our commissioned independent science is that while there is strong indirect evidence that salmon farms operating

in the Broughton Archipelago contribute to increased sea lice levels, farms can manage their operations in such a way that reduces risk of sea lice infection. Support of adaptive management strategies, such as coordinated area production planning, needs to be continued in the Broughton and applied in other fish farming areas to ensure salmon farming has a positive future in BC. Collaborative, science-based approaches to resource industry development also need to be continued to enable solutions-based approaches in our watersheds and marine systems.

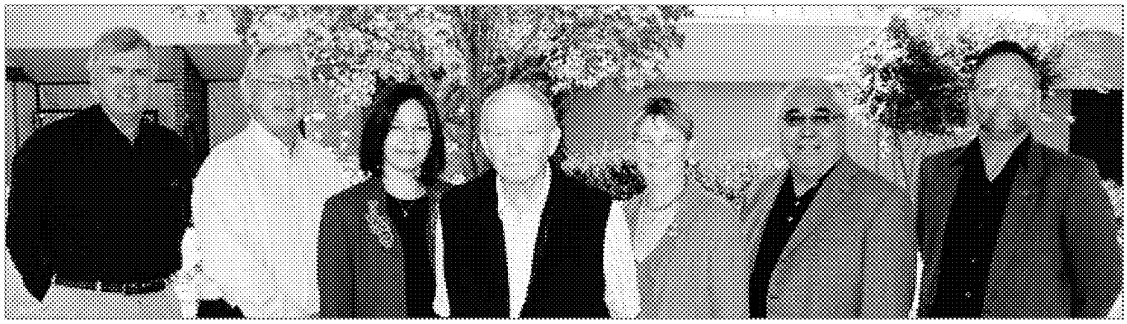
In 2005 you called for British Columbia to have the best managed fisheries bar none. We hope that our recommendations will constitute a road map toward that goal and offer a way out of the controversies that have dogged "the salmon question" in this Province for many years.

We want to thank you for the opportunity to serve the Province in this important initiative. We submit the following report and recommendations to the Government of British Columbia.

Sincerely,



BC Pacific Salmon Forum Board Members L-R John Woodward, Jim Lornie, Teresa Ryan, Chairman John Fraser, Christina Burridge, Harry Nyce Sr., Jeremy Maynard



EXECUTIVE SUMMARY

Even a cursory search of newspaper headlines in recent years makes it plain that wild and farmed salmon in British Columbia are synonymous with conflict, mistrust and confusion. Story after story, scientific report after scientific report, court case after court case has presented a picture of impending doom - declining wild salmon runs, eternally squabbling resource users, rapacious developers, irresponsible salmon farmers - all presided over by inept and uncaring governments.

Following our work, we have concluded that in terms of sustaining wild salmon the current system of governance for salmon is inadequate. We were charged, in part, to suggest a path upward to a better future.

Where should change begin? Wild salmon begin their lives in watersheds and that's where public policy change should begin as well. We know that in certain watersheds salmon populations are already struggling. We know that watersheds are under pressure from multiple human activities including urban development. We also know that climate change is going to intensify these pressures in ways that we have scarcely begun to imagine.

Our governance systems have not adapted well to these challenges. Regulatory processes for salmon farming, forestry, mining, power development and other activities are not well understood by the public and do not enjoy a high level of public confidence. 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. Public confidence in 'the system' is low. Public realization that all of us need to face some difficult value choices is only beginning to coalesce.

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.

Our ecosystem management recommendations, if implemented, will strengthen watersheds and make them more resilient to climate change and human use while securing time for wild salmon to rebuild and thrive. Our governance recommendations will ensure that all land and water use decisions that affect salmon will be made efficiently and effectively, by a single agency. Our salmon aquaculture recommen-

dations will establish key indicators of ecosystem health and ensure that salmon farms are managed in a coordinated area approach that protects those indicators. We believe that our recommendations on public confidence will increase public trust that difficult choices ahead will be made sensibly, openly and transparently, and in light of the best possible information.

The sustainability of wild salmon is vital to British Columbia's cultural and economic fabric. Thriving wild salmon tell us that our ocean and freshwater ecosystems are healthy. Wild and farmed salmon sectors are vital to local coastal economies.

Today, in many watersheds across the Province, wild salmon are declining. Future growth in salmon farming is uncertain due to concern over its impacts on the environment. BC will also face unprecedented changes in climate over the coming decades that will significantly increase threats to the long-term viability of wild salmon in our watersheds and oceans.

We believe that the current governance of both wild and farmed salmon is simply not adequate to address these threats and requires transformative change immediately to ensure that wild salmon have a vibrant future in BC. This future will include:

Application of an ecosystem-based approach to managing all resource industries - including salmon farming - in watersheds and marine environments.

To halt continued habitat loss and address future impacts resulting from climate change, we propose that British Columbia implement an ecosystem-based management approach for all resource industries. This will require a shift from present fragmented practices to managing watersheds holistically as ecosystems, increasing their capacity to accommodate change. This approach will mean establishing and monitoring ecosystem indicators such as temperatures, hydrological flows, riparian conditions and water quality. Decisions on resource uses can then be adapted to ensure that we stay within ecosystem capacities rather than exceeding them, as can now be the case in demand-driven regulatory decisions.

A shift to a new governance system to ensure the future of BC's wild and farmed salmon resources and their habitat.

In the future it will be imperative that all provincial land and water managers understand what is required to keep streams healthy, taking into account the cumulative impacts of all decision-making. It is very difficult to do this within the current system where a variety of individual ministries and agencies operate in separate 'silos,' making uncoordinated decisions that can impact a single watershed, without considering the cumulative impacts of multiple decisions on the watershed or marine system.

A new provincial governance system will require many changes, beginning with the creation of a single Water and Land Agency responsible for making all water and land decisions in watersheds in accordance with ecosystem principles. It will also require that federal, provincial, First Nations and local government collaborate on watershed governance, and that 'ecosystem goods and services' such as carbon storage are valued in decisions. It will require that the provincial and federal governments strengthen habitat restoration and enhancement projects to maintain, rebuild or restore natural biodiversity and abundance in wild salmon stocks. It will also require that the Province

implement coordinated area management plans for salmon aquaculture to support a fully integrated adaptive management approach.

The adoption of an ecosystem-based approach to managing salmon farms in the Broughton Archipelago as a pilot. Results from this pilot will form a template for salmon aquaculture management in other areas of British Columbia.

In keeping with an ecosystem-based approach, we see salmon farming managed in accordance with performance-based ecosystem thresholds that will be measured and reported on publicly. In the Broughton Archipelago we support the adoption of a coordinated area management approach to enable optimum benefit for adaptive management practices such as integrated pest and disease management to ensure any risk to wild salmon is reduced.

Based on interim research findings, we have established ecosystem objectives for managing sea lice on farms and wild out-migrating salmon smolts in the spring in the Broughton. These objectives should be verified through additional monitoring during the spring of 2009. The principles of this ecosystem-based approach in the Broughton must be applied to other areas in the Province where salmon farms exist or are considered.

The immediate creation of an independent regulatory oversight authority that will report publicly through the Legislature.

A new regulatory oversight body will audit the provincial regulatory process ensuring that all decisions in watersheds and in the marine environment meet required ecological outcomes. It will also provide public confidence that resource industries are in compliance with regulation.

The building of public trust in the sustainability of the wild fishery and salmon farming through collaboration and information sharing and the orientation of scientific research and public debate toward solutions and away from the advancement of positions.

Public distrust in government management of both wild and farmed salmon has been exacerbated by publication of scientific papers and associated media reports that advance conflicting claims concerning the possible effects of salmon farming on wild salmon. Industry distrusts the findings of research originating from conservation groups; ENGOs distrust studies carried out by scientists connected to government or business. Too little science is seen as agenda-free.

One of the Forum's most successful accomplishments was to bring together a variety of scientific perspectives in a coordinated approach to research. In order to continue this work, we recommend the establishment of a Science Secretariat. This secretariat could commission independent, peer-reviewed science to seek better understanding of the relationship between salmon and their environment and other ecosystem-based management approaches in watersheds.

The Forum believes that the best way to build trust among all stakeholders will be to create processes and structures that engage all stakeholders, particularly First Nations, and encourage them to work together using the results of ecosystem-based science to inform discussions and decisions.

Both federal and provincial regulators and the broader science community must accept responsibility for providing more consistent and effective public information and education.

To inform research, all resource industries, including salmon farming, must be required to share pertinent information with British Columbians in keeping with their use of public resources.

Only by managing watersheds and the marine environment on an ecosystem basis, ensuring that cumulative impacts are being fully and transparently monitored, and by the provincial government coordinating decision-making in watersheds, will there be a sustainable future for salmon in the Province.

Bringing closure to the debate about closed containment salmon farming by subjecting this concept to a rigorous commercial-scale demonstration project beginning with the issuance of a request for proposals during 2009.

In BC several groups as well as the Special Committee on Sustainable Aquaculture have called for the imposition of water-based or land-based closed containment technology for salmon farming.

There is a high degree of public misinformation on closed containment and many questions to be answered before it can be considered viable. To resolve these questions and put this debate on a factual footing, the Forum recommends that the Province establish an independent technical committee to develop the specifications for a closed containment pilot project. This review and any subsequent process of implementing the pilot project must be transparent so that the public is kept fully informed.

FORUM RECOMMENDATIONS

On the basis of our work since 2005, the Forum recommends that the Province of British Columbia:

APPLY AN ECOSYSTEM-BASED APPROACH TO MANAGING ALL RESOURCES IN WATERSHEDS AND MARINE ENVIRONMENTS

1. STRENGTHEN ECOLOGICAL RESILIENCE TO SUPPORT WILD SALMON AND OTHER RESOURCE VALUES THROUGH THE APPLICATION OF AN ECOSYSTEM-BASED APPROACH TO MANAGING WATERSHEDS

   Rationale:

   » The ecosystem-based approach requires a major management shift from the current situation whereby individual provincial agencies make resource decisions separately and without a joint understanding of ecosystem carrying capacity or cumulative impacts, to one that considers the capacity of the whole watershed to accommodate change

   » Strengthening ecosystem resilience of watersheds enables them to sustain diverse salmon populations and to better adapt to climate change

   » The Province's existing Integrated Land and Resource Registry must be adapted to support the ecosystem-based approach by tracking all water and land use decisions in watersheds

2. BY 2012, ESTABLISH A PRACTICAL SET OF ECOSYSTEM INDICATORS FOR WATERSHEDS AND MARINE SYSTEMS

   Rationale:

   » Federal and provincial agencies have begun to identify ecosystem indicator values for healthy watersheds and marine systems. This work should be completed and pilot tested on key watersheds.

   » Ecosystem indicators such as water temperature, integrity of riparian systems, water quality, stream flows and wildlife values required to support fish and their habitat will act as constraints and place limits on the type and nature of resource use in watersheds in order to maintain their proper functioning condition

   » First Nations' traditional knowledge and expertise should be utilized in establishing habitat and ecosystem indicators

3. BY THE END OF 2009, LINK MEASURES TO MEET THE PROVINCIAL CARBON BUDGET WITH MEASURES DESIGNED TO SUPPORT WILD SALMON IN WATERSHEDS

   Rationale:

   » Through existing practices and new measures to restore and protect proper functions, managing watersheds can be a potential offset in

provincial carbon management policies and eligible for funding through the BC Pacific Carbon Trust

» Ecological goods and services in watersheds must be valued and brought into resource management decision-making by all levels of government

» Inclusion of carbon budgets and ecosystem services evaluations will strengthen the business case for implementing ecosystem-based watershed management

4. IMMEDIATELY ENTER INTO AGREEMENTS WITH THE FEDERAL GOVERNMENT TO STRENGTHEN AND IMPLEMENT HABITAT RESTORATION AND ENHANCEMENT PROGRAMS TO MAINTAIN, REBUILD OR RESTORE NATURAL BIODIVERSITY AND ABUNDANCE OF WILD SALMON

Rationale:

» Salmon enhancement should be based on sound science and ensure the protection of both genetic resiliency and weaker stocks for conservation

» Water management must recognize the broad value of freshwater ecosystems and the importance of their protection in the public interest

» Funding and human resources for habitat restoration and water stewardship programs must be optimized through collaboration between governments, First Nations, local community volunteer organizations, conservation foundations and corporations

SHIFT TO A NEW GOVERNANCE SYSTEM TO ENSURE THAT BC'S WILD AND FARMED SALMON RESOURCES AND HABITAT ARE MANAGED IN ACCORDANCE WITH ECOSYSTEM-BASED PRINCIPLES

5. BY 2012 CREATE AN EFFECTIVE BC WATER AND LAND AGENCY RESPONSIBLE FOR MAKING ALL RESOURCE USE DECISIONS IN WATERSHEDS AND MARINE SYSTEMS

Rationale:

» A BC Water and Land Agency will ensure consistency in applying ecosystem indicator values for all land and water decisions in watersheds and in the marine environment to all resource industries, including aquaculture, ensuring the cumulative effects of multiple decisions do not exceed established ecosystem health indicators

» Decision makers will understand what is required to keep streams healthy to provide a full range of ecosystem goods and services and make their decisions accordingly

» Support will be available to First Nations to enable them to participate in meaningful consultation on the transition to this new form of watershed and marine system governance

» Regulations will be streamlined across all levels of governments to avoid duplication and overlaps and ensure timely decision-making

» Siting proposals for all resource industries (e.g. aquaculture, forestry, mining) that comply with all established ecosystem thresholds and constraints will receive streamlined regulatory approvals

6. BY 2010, ALL LEVELS OF GOVERNMENT COLLABORATE ON PILOT WATERSHED GOVERNANCE PROJECTS DESIGNED SPECIFICALLY TO STRENGTHEN ECOSYSTEM MANAGEMENT OF WATERSHEDS

   Rationale:

   » The Province must lead in enabling a revised governance approach with First Nations, federal and local governments and community stakeholders in pilot watersheds. The goal of this change should be to establish practical procedures to ensure that watersheds are managed to function as ecological units.

   » Working with community stakeholders, the Province should ensure they are engaged in decision-making processes to build understanding and trust in provincial regulatory processes and regimes

7. TAKE MEASURES TO SUPPORT THE ECONOMIC AND SOCIAL RESILIENCE OF COMMUNITIES THROUGH THE DEVELOPMENT OF DIVERSIFIED ECONOMIES

   Rationale:

   » The economic future of many communities is already challenged because traditional resource industries no longer provide the previous level of economic stability to their citizens; climate change will have a further significant economic impact

   » Adaptive management must be practiced by all resource industries enabling them to operate within an ecosystem-based approach

   » Community stakeholders must be engaged in risk assessments based on ecosystem thresholds. When new resource development opportunities are being considered, the community must be provided with factual and relevant information that will support informed choices.

   » Open and transparent information must be provided to communities on such topics as regulation and regulatory approval processes, baseline research, habitat and ecosystem monitoring

ADOPT THE ECOSYSTEM-BASED APPROACH TO ADDRESS POTENTIAL IMPACTS FROM SALMON AQUACULTURE IN BRITISH COLUMBIA

8. SET PERFORMANCE-BASED INDICATORS FOR FARMED SALMON PRODUCTION AND SUPPORT A COORDINATED AREA MANAGEMENT APPROACH IN THE BROUGHTON ARCHIPELAGO BEGINNING IN 2009

   Rationale:
   Based on interim research results in the Broughton, the Forum has reached the following conclusions:

   » No more than 3% of juvenile wild pink and chum salmon of less than 0.5 grams should have more than one pre-adult or later stage *L. salmonis* between March 1 and May 31, based on the estimated natural background of lice in the Broughton

   » All companies must strictly adhere to the coordinated area management plan in the Broughton for 2009 to minimize any incremental risk associated with sea lice contributed by salmon farming

   » The coordinated area management plan together with a scientifically supportable monitoring program of sea lice on both farmed and wild

fish must be continued for at least the next five years with an evaluation using the Finite Volume Coastal Ocean Model, a new analytical tool developed through Forum research

» A limit on annual production initially to 18,500 tonnes of farmed fish (the average annual production between 1999 and 2007) as a precautionary approach to protecting wild salmon returns

» This production limit can be adjusted based on an independent review of the interim research results, evaluation of the 2009 coordinated management plan, evaluation of individual farm sites based on the Finite Volume Ocean Coastal Model and other research recommended by the Forum

» The Forum urges all relevant parties to work together to allow the implementation of the coordinated production management approach and the scientific evaluation to extend from 2009 to 2014

9. APPLY THE ECOSYSTEM-BASED APPROACH PILOTED FOR SALMON AQUACULTURE IN THE BROUGHTON ARCHIPELAGO TO OTHER COASTAL REGIONS OF BRITISH COLUMBIA

Rationale:

» The Finite Volume Coastal Ocean Model must be evaluated by the proposed Science Secretariat in 2009 so that it can be adapted and used in other areas

» Expand collaborative scientific research to other areas to ensure that ecosystem indicator thresholds are identified, monitored and reported

» Amend current regulations to reflect appropriate thresholds for sea lice prevalence and intensity in all salmon farming regions in the Province, based on natural background levels, during the juvenile salmon out-migration period. Until it is demonstrated that these environmental thresholds can be met, salmon production outside the Broughton should be subject to a conditional limit based on the production average between 1999 and 2007 (or appropriate historical average). In terms of lice management, the level of production in the future would be contingent upon meeting the appropriate threshold for the ecosystem in which the farm is located.

» The Province should provide regulatory support for the testing and commercialization of polyculture (integrated multi-trophic aquaculture that grows different finfish, shellfish and plants together) as an adaptive management approach for risk reduction in the Broughton and elsewhere

» The application of adaptive management approaches will reduce risk and integrate risk management practices into decision-making

10. ADOPT A COORDINATED AREA MANAGEMENT APPROACH TO SALMON AQUACULTURE THROUGHOUT THE PROVINCE

Rationale:

» A coordinated area management approach should include all salmon farms operating within designated areas and ensure that local stakeholders are engaged in transparent monitoring of established ecosystem thresholds for farm operations

» Confidence will increase as information is shared in local areas, building trust through open dialogue and access to farm data pertinent to the industry's use of a public resource

» Coordinated management of farms ensures operational efficiencies, improved disease and pest management as well as adaptive management practices that safeguard wild salmon

» Threshold targets for sea lice during the juvenile salmon out-migration period as developed in the Broughton should also be established

11. WORKING WITH THE SALMON FARMING INDUSTRY, ADOPT INTEGRATED PEST MANAGEMENT AND INTEGRATED DISEASE MANAGEMENT APPROACHES TO SALMON FARM MANAGEMENT

Rationale:

» Supported by a coordinated area management approach, access to a variety of options for treatment of both parasites and disease will result in a long-term reduction in the application of chemical therapeutants

» The Province must insist that Health Canada develop a transparent and speedy process for the review and licensing of all veterinary drug products including SLICE™ (Emamectin Benzoate)

» To support this change the Province must practice a transparent and timely process to review and establish protocols for non-drug treatments for on-farm disease and parasite management

BUILD PUBLIC CONFIDENCE IN WILD AND FARMED SALMON MANAGEMENT THROUGH OVERSIGHT, COLLABORATION AND IMPROVED SCIENCE WITH A FOCUS ON SOLUTIONS VERSUS ADVANCEMENT OF POSITIONS

12. BY THE END OF 2009 ESTABLISH AN INDEPENDENT PROVINCIAL REGULATORY OVERSIGHT AUTHORITY TO MONITOR AND AUDIT DECISIONS THAT AFFECT WATERSHEDS IN ACCORDANCE WITH PROPOSED ECOSYSTEM-BASED INDICATORS. THIS BODY SHOULD REPORT REGULARLY TO THE PUBLIC THROUGH THE LEGISLATURE

Rationale:

» This oversight authority should be established with an initial four-year mandate; any extension would be determined following an evaluation in 2013

» The oversight authority should audit the regulatory process to ensure watershed and marine system management is based on ecosystem principles

» The authority should ensure the implementation of an ecosystem-based approach to managing resources in watersheds and marine environments in British Columbia

» The authority will audit progress toward implementing the Forum's recommendations including any necessary regulatory changes and the establishment of a single Water and Land Agency and a Science Secretariat

» The authority should have the capacity to identify overlaps or conflicts in watersheds between the four levels of government – federal, provincial, First Nations and local

» The authority must have access to all information relevant to its mandate

13. ESTABLISH A SCIENCE SECRETARIAT TO SERVE AS A CENTRE OF EXCELLENCE FOR ECOSYSTEM-BASED RESEARCH ON MARINE AND WATERSHED SYSTEMS THAT SUPPORT SALMON

    Rationale:

    » A Science Secretariat will facilitate a coordinated, collaborative approach that includes a variety of disciplines and perspectives and links BC's ecosystem-based research with the international community

    » Core funding would be provided through federal and provincial governments

    » New emphasis and funding must be given to research into the ways that salmon survival is being impacted by changing conditions in the Pacific Ocean

    » The Science Secretariat must ensure that all its research findings are communicated in plain language

    » An interim Science Secretariat should conduct an independent review of the research funded by the BC Pacific Salmon Forum and report by the fall of 2009

14. THIRD-PARTY CERTIFICATION FOR COMMERCIAL SALMON FISHERIES AND SALMON AQUACULTURE IN BC MUST BE ENCOURAGED BY THE PROVINCE

    Rationale:

    » Federal and provincial governments should support certification by the Marine Stewardship Council or another equivalent independent certification system for commercial salmon fisheries

    » Federal and provincial governments should support certification of farmed salmon and the development of a certification program for aquaculture with standards based on ISO65

15. ALL RESOURCE INDUSTRIES, INCLUDING SALMON FARMING, MUST BE REQUIRED TO SHARE PERTINENT INFORMATION WITH BRITISH COLUMBIANS IN KEEPING WITH THEIR USE OF A PUBLIC RESOURCE

    Rationale:

    » Researchers and the public are entitled to data from resource development required for ecosystem-based management

    » Government agencies must provide timely public reporting on all regulatory reviews, inspections and audits conducted on resource industries

DESIGN AND IMPLEMENT A COMMERCIAL-SCALE TRIAL OF A CLOSED CONTAINMENT SYSTEM FOR RAISING FARMED SALMON

16. IMMEDIATELY ESTABLISH AN INDEPENDENT TECHNICAL COMMITTEE TO RECOMMEND SPECIFICATIONS FOR A COMMERCIAL-SCALE CLOSED CONTAINMENT DEMONSTRATION PROJECT. AS SOON AS THERE IS AGREEMENT ON THE TECHNICAL PARAMETERS, THE PROVINCE WORKING WITH OTHER INTERESTED PARTIES SHOULD ISSUE A REQUEST FOR PROPOSALS FOR THE DEMONSTRATION PROJECT TO RECOVER WASTES AND REDUCE THE RISK OF LICE AND DISEASE TRANSFER TO THE NATURAL ENVIRONMENT

    Rationale:

    » A closed containment system must ensure that ecosystem-based indicators – such as a significant reduction in the risk of lice and disease

transfer to the natural environment – are effectively achieved

» Currently there is no commercial-scale closed containment production of salmon; the technical committee should use the work completed by the Canadian Science Advisory Secretariat to undertake an analysis of technical specifications

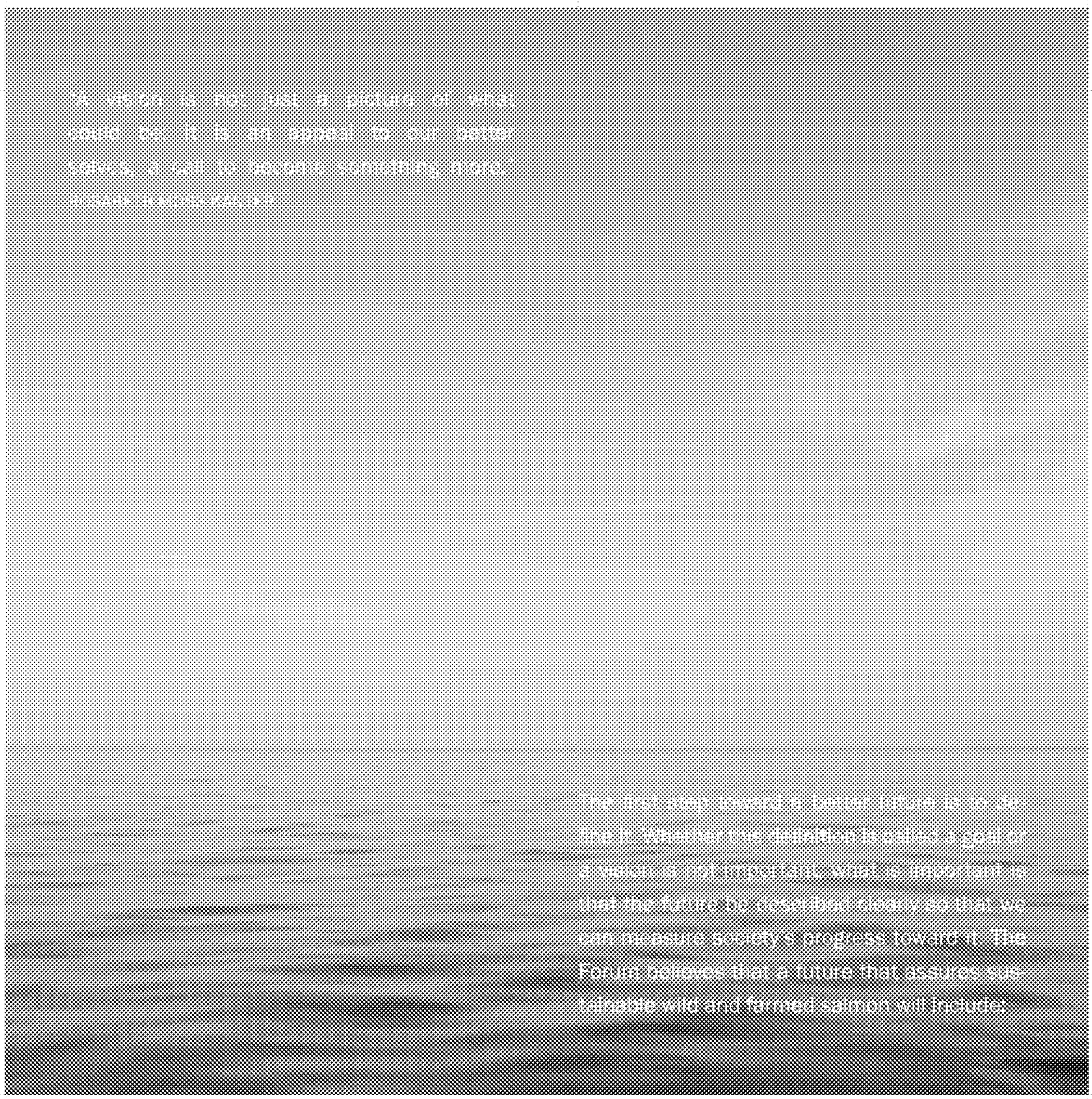
» During 2009, the committee should develop project specifications and subsequently issue a request for proposals that will procure final design, construction and operation in accordance with best business practices

» The committee should ensure transparent communication with the public throughout the project

» The committee could advise on additional species production to enhance the profitability of the demonstration project

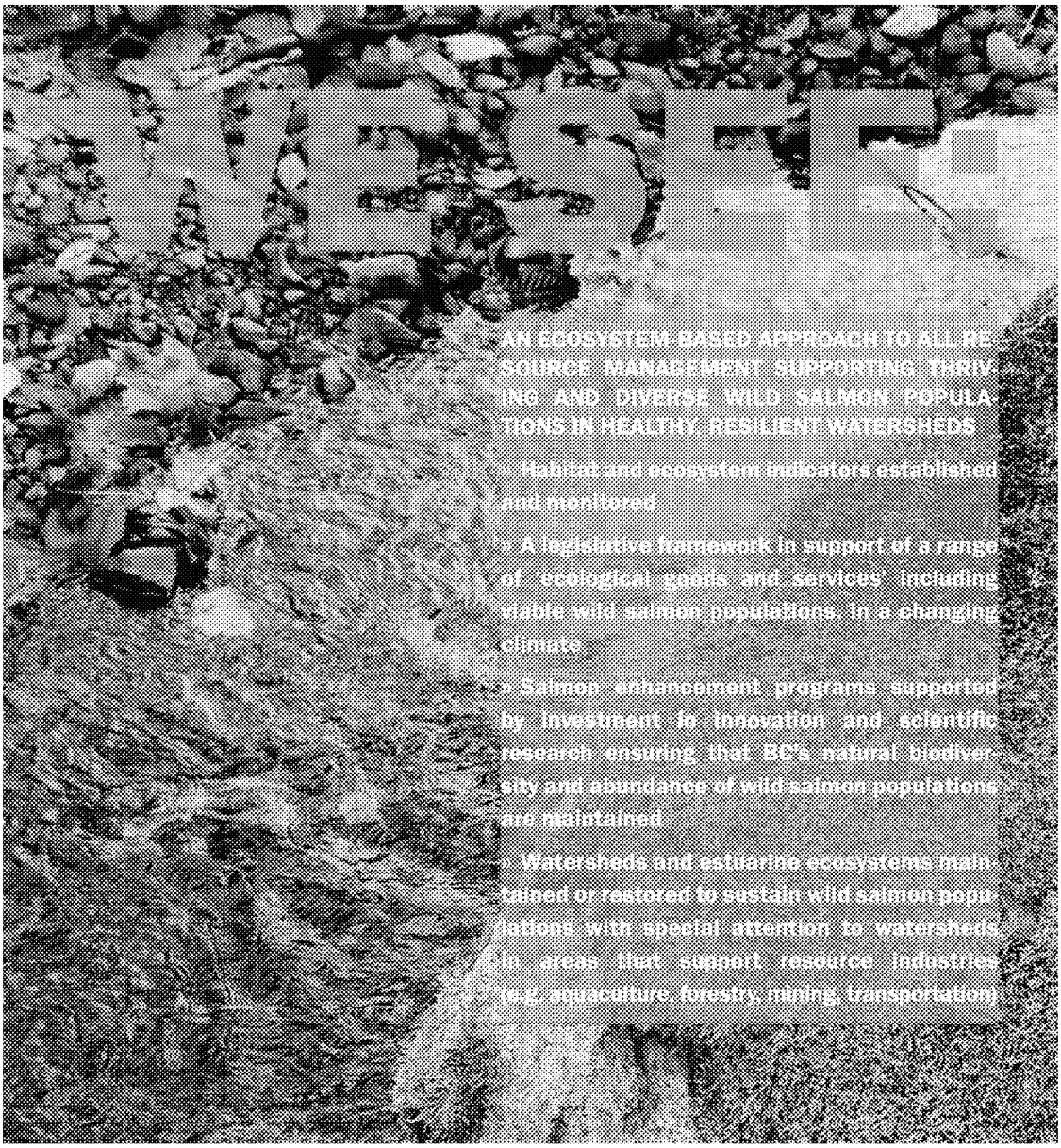
The Forum expects the Government of British Columbia will enact the appropriate legislative and regulatory measures to ensure implementation of these recommendations. Voluntary compliance by corporate interests - whether salmon farming, forestry, mining, or power development - is not sufficient.

SUSTAINING A FUTURE FOR BC SALMON



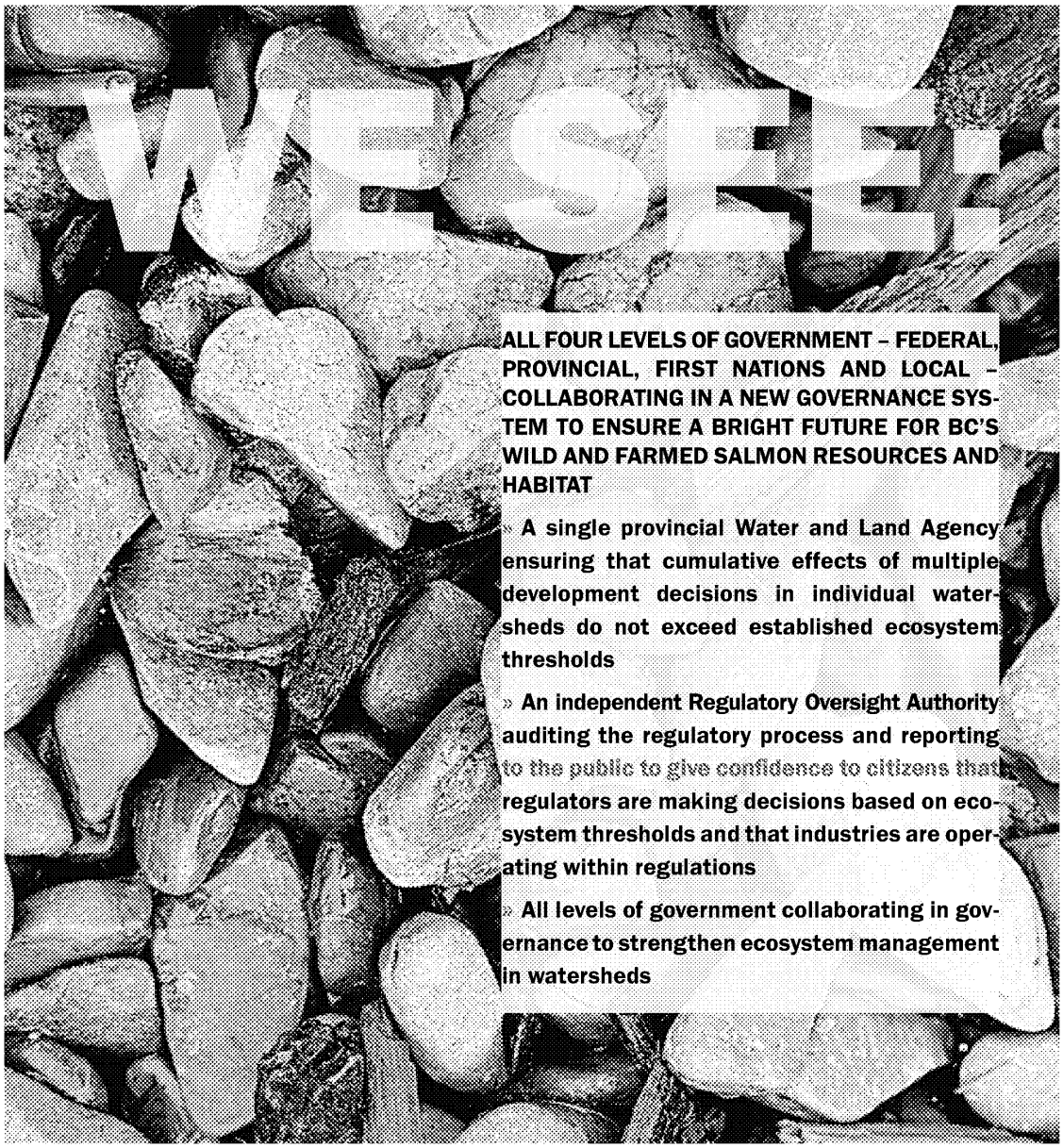
"A vision is not just a picture of what could be; it is an appeal to our better selves, a call to become something more."
ROSABETH MOSS KANTER

The first step toward a better future is to define it. Whether the definition is called a goal or a vision is not important; what is important is that the future be described clearly so that we can measure society's progress toward it. The Forum believes that a future that assures sustainable wild and farmed salmon will include:



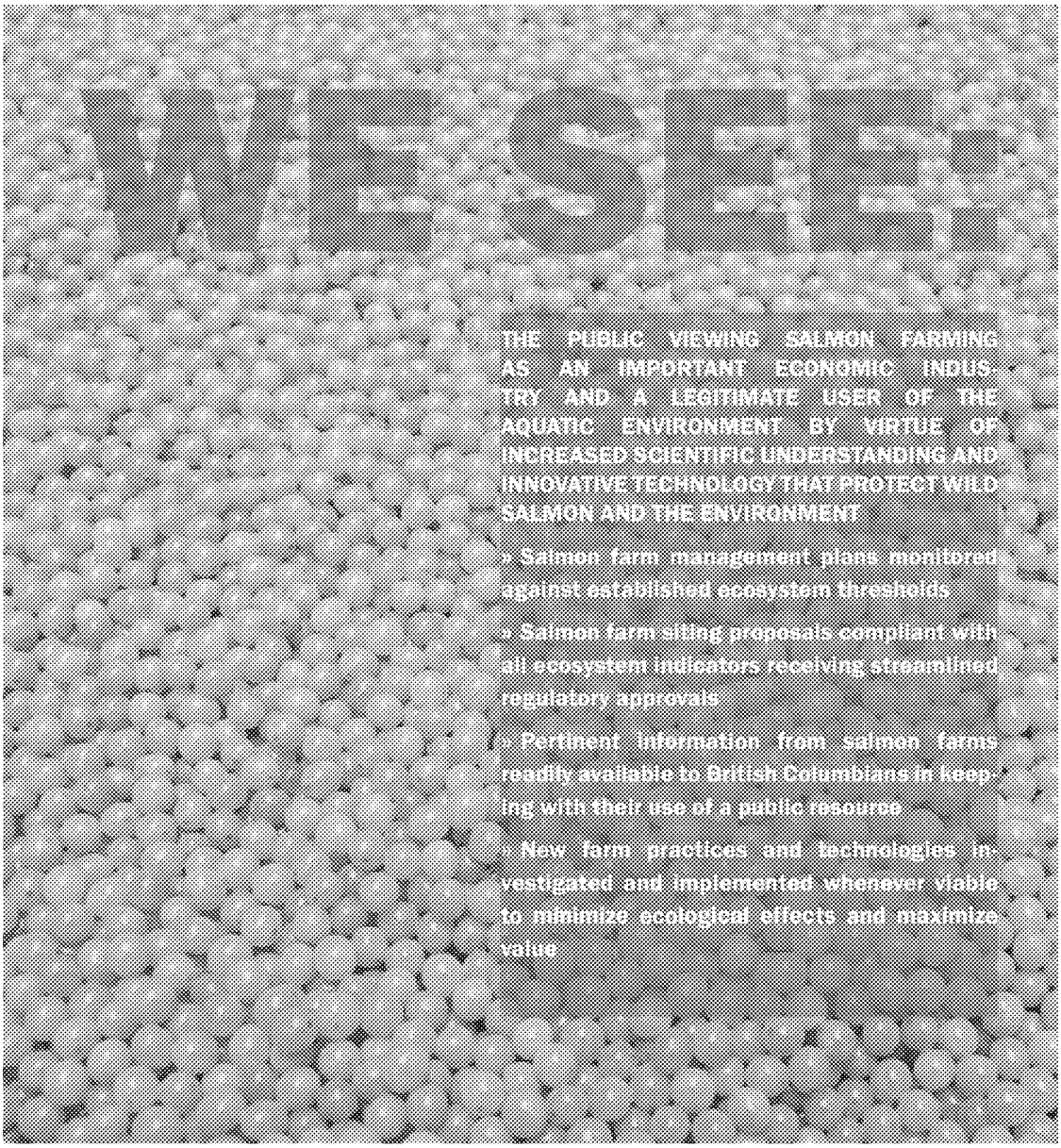
AN ECOSYSTEM BASED APPROACH TO ALL RESOURCE MANAGEMENT SUPPORTING THRIVING AND DIVERSE WILD SALMON POPULATIONS IN HEALTHY, RESILIENT WATERSHEDS

- Habitat and ecosystem indicators established and monitored
- A legislative framework in support of a range of 'ecological goods and services' including viable wild salmon populations, in a changing climate
- Salmon enhancement programs supported by investment in innovation and scientific research ensuring that BC's natural biodiversity and abundance of wild salmon populations are maintained
- Watersheds and estuarine ecosystems maintained or restored to sustain wild salmon populations with special attention to watersheds in areas that support resource industries (e.g. aquaculture, forestry, mining, transportation)



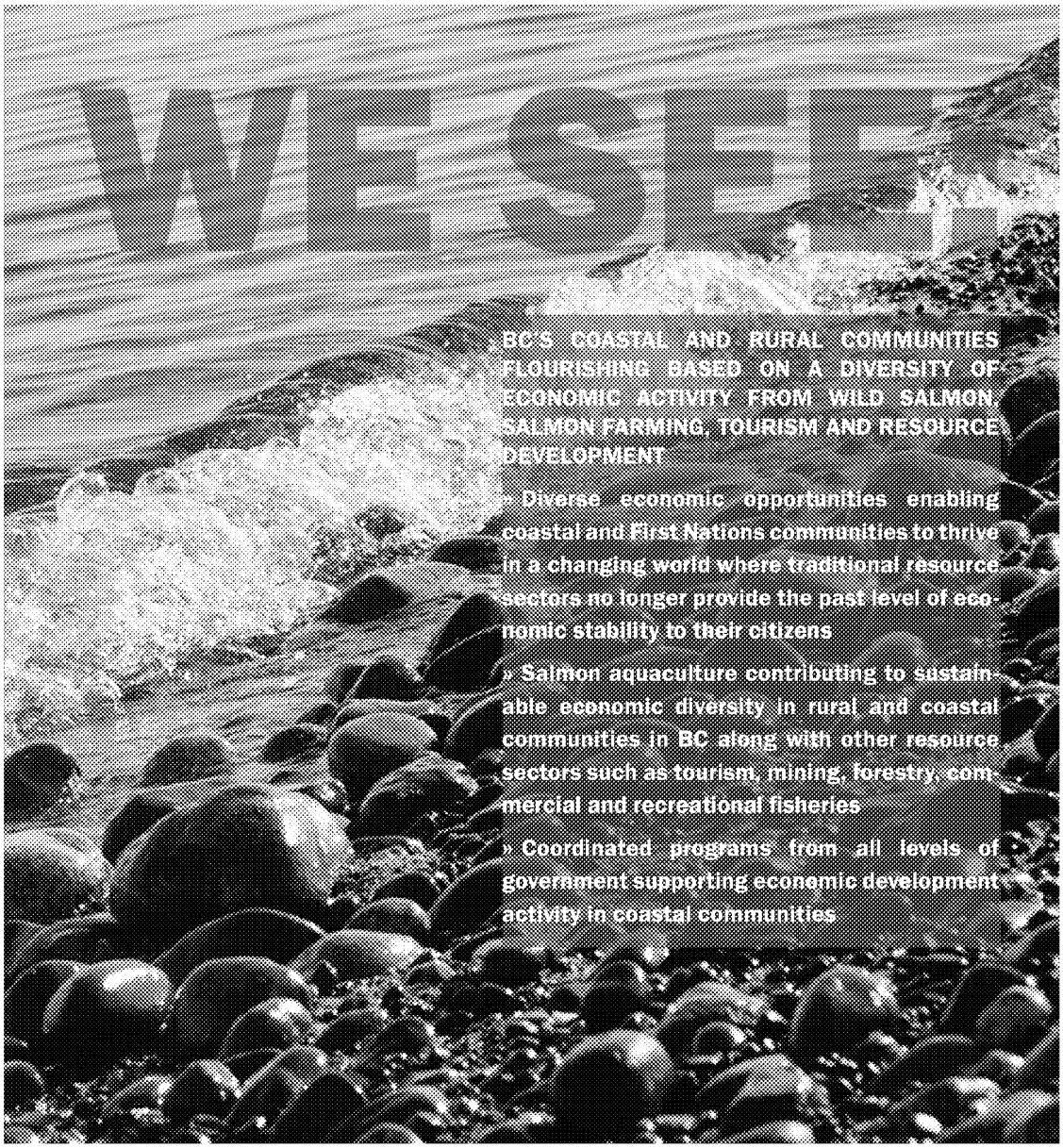
ALL FOUR LEVELS OF GOVERNMENT – FEDERAL, PROVINCIAL, FIRST NATIONS AND LOCAL – COLLABORATING IN A NEW GOVERNANCE SYSTEM TO ENSURE A BRIGHT FUTURE FOR BC'S WILD AND FARMED SALMON RESOURCES AND HABITAT

- **A single provincial Water and Land Agency ensuring that cumulative effects of multiple development decisions in individual watersheds do not exceed established ecosystem thresholds**
- **An independent Regulatory Oversight Authority auditing the regulatory process and reporting to the public to give confidence to citizens that regulators are making decisions based on ecosystem thresholds and that industries are operating within regulations**
- **All levels of government collaborating in governance to strengthen ecosystem management in watersheds**



THE PUBLIC VIEWING SALMON FARMING AS AN IMPORTANT ECONOMIC INDUSTRY AND A LEGITIMATE USER OF THE AQUATIC ENVIRONMENT BY VIRTUE OF INCREASED SCIENTIFIC UNDERSTANDING AND INNOVATIVE TECHNOLOGY THAT PROTECT WILD SALMON AND THE ENVIRONMENT

- Salmon farm management plans monitored against established ecosystem thresholds
- Salmon farm siting proposals compliant with all ecosystem indicators receiving streamlined regulatory approvals
- Pertinent information from salmon farms readily available to British Columbians in keeping with their use of a public resource
- New farm practices and technologies investigated and implemented whenever viable to minimize ecological effects and maximize value



BC'S COASTAL AND RURAL COMMUNITIES FLOURISHING BASED ON A DIVERSITY OF ECONOMIC ACTIVITY FROM WILD SALMON, SALMON FARMING, TOURISM AND RESOURCE DEVELOPMENT

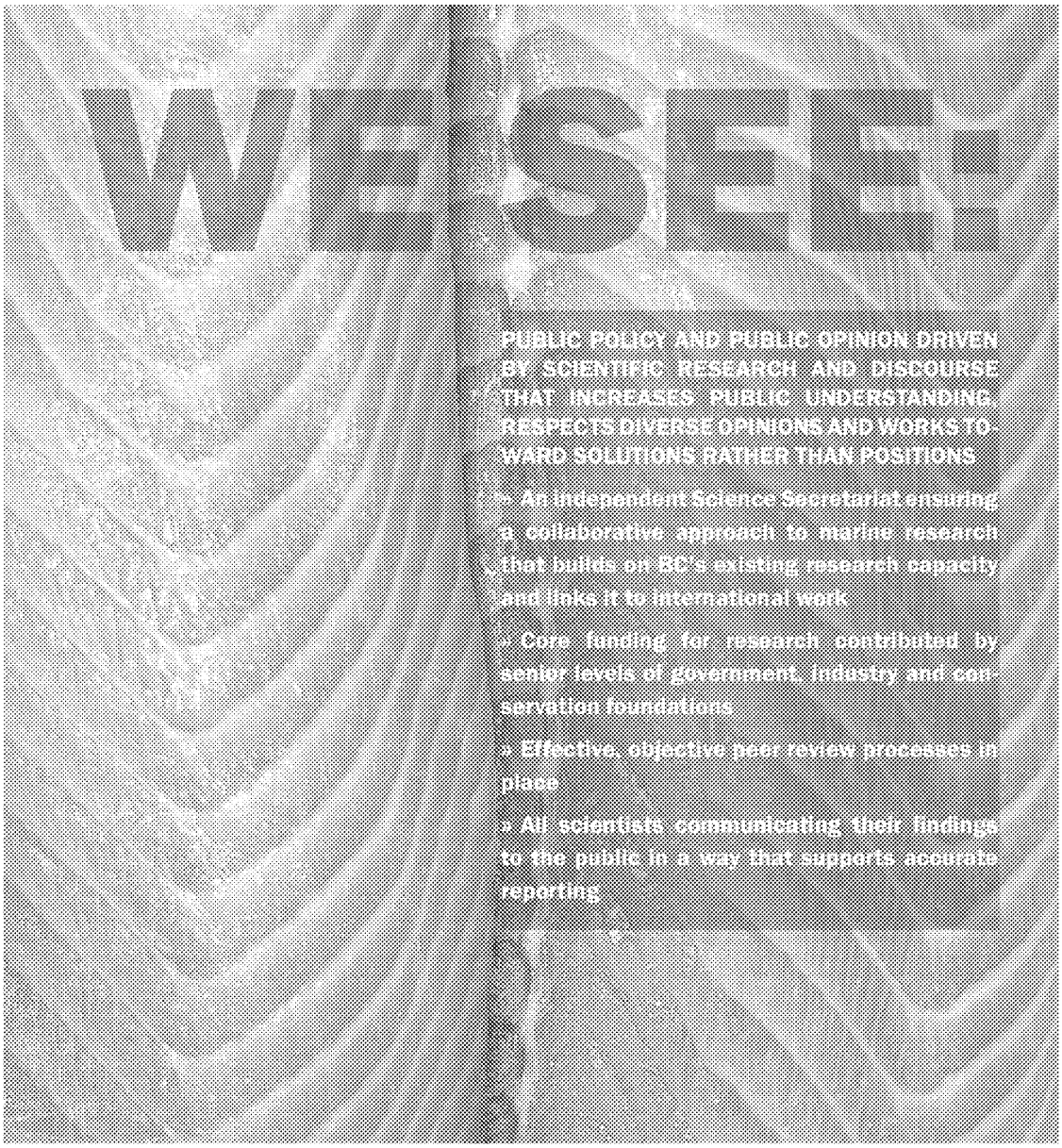
» Diverse economic opportunities enabling coastal and First Nations communities to thrive in a changing world where traditional resource sectors no longer provide the past level of economic stability to their citizens

» Salmon aquaculture contributing to sustainable economic diversity in rural and coastal communities in BC along with other resource sectors such as tourism, mining, forestry, commercial and recreational fisheries

» Coordinated programs from all levels of government supporting economic development activity in coastal communities

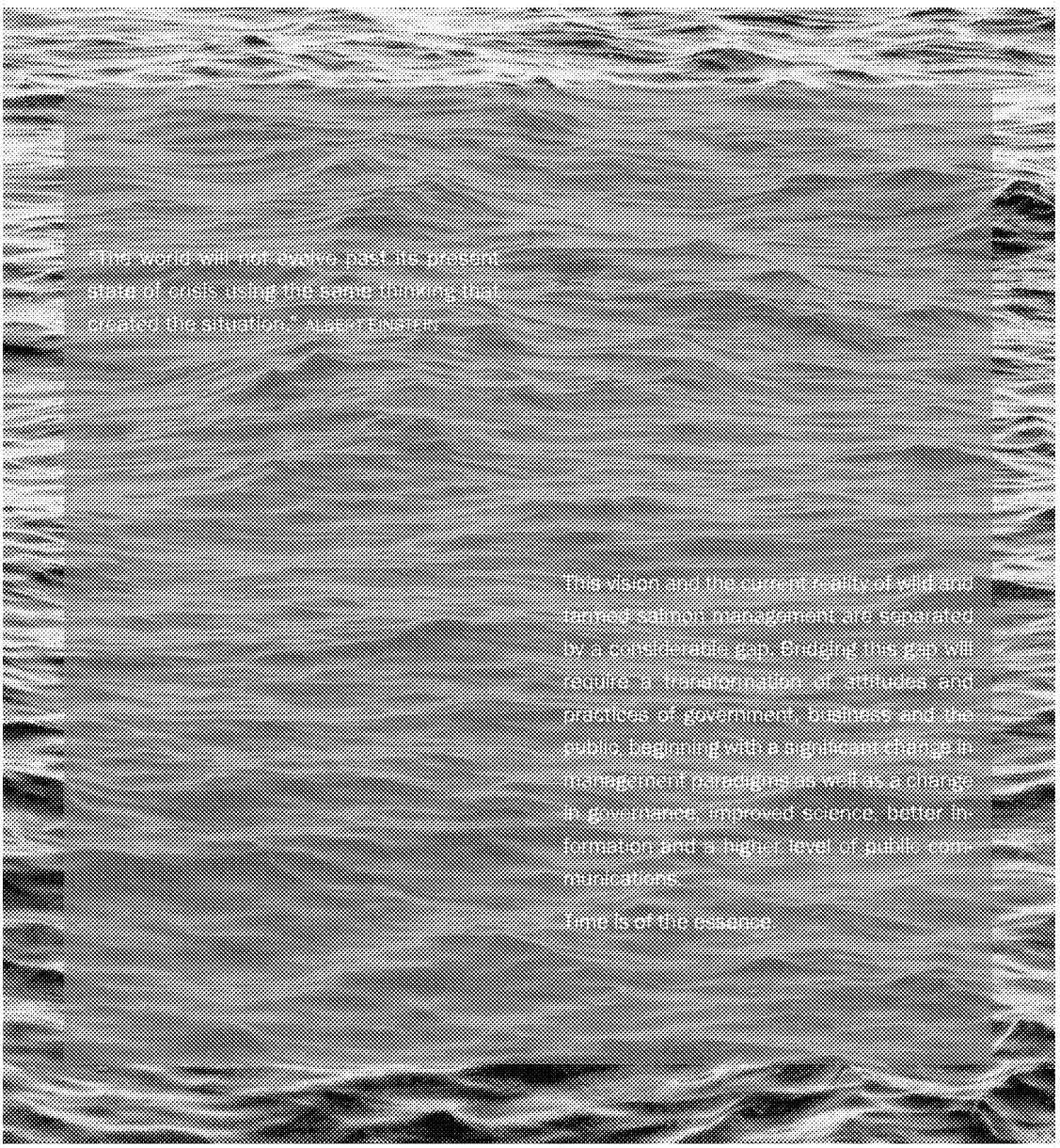
BC'S FIRST NATIONS FULLY ENGAGED IN ECOSYSTEM-BASED MANAGEMENT WITHIN THEIR TRADITIONAL TERRITORIES

- First Nations' knowledge and expertise utilized in establishing habitat and ecosystem indicators
- First Nations becoming key participants in resource management decision-making
- Funding sources available to build capacity within First Nations, enabling them to participate in maintaining healthy watersheds and marine systems for wild and farmed salmon production



PUBLIC POLICY AND PUBLIC OPINION DRIVEN BY SCIENTIFIC RESEARCH AND DISCOURSE THAT INCREASES PUBLIC UNDERSTANDING, RESPECTS DIVERSE OPINIONS AND WORKS TOWARD SOLUTIONS RATHER THAN POSITIONS

- An independent Science Secretariat ensuring a collaborative approach to marine research that builds on BC's existing research capacity and links it to international work
- Core funding for research contributed by senior levels of government, industry and conservation foundations
- Effective, objective peer review processes in place
- All scientists communicating their findings to the public in a way that supports accurate reporting



"The world will not evolve past its present state of crisis using the same thinking that created the situation." Albert Einstein

The vision and the current reality of wild and farmed salmon management are separated by a considerable gap. Bridging this gap will require a transformation of attitudes and practices of government, business and the public, beginning with a significant change in management paradigms as well as a change in governance, improved science, better information and a higher level of public communications.

Time is of the essence.

THE BIG PICTURE: AN OVERVIEW

"The salmon are a test of a healthy environment, a lesson in environmental needs. Their abundant presence on the spawning grounds is a lesson in hope, a reassurance that all is well with water and land, a lesson of deep importance for the future of man. If there is ever a time when the salmon no longer return, man will know he has failed again and moved one step nearer to his own final disappearance."

RODERICK HAIG-BROWN
THE SALMON, 1974

The BC Pacific Salmon Forum was appointed by Premier Campbell in December 2004. Our mandate was to develop policy recommendations to protect and enhance the viability of wild salmon stocks[1] and the economic, social and environmental benefits to British Columbians; enhance the economic social and environmental sustainability of aquaculture for all coastal communities; and increase public confidence in fisheries management generally, and aquaculture in particular, in the marine environment.

In order to generate balanced public policy recommendations, the members of the Forum, each familiar with salmon and their value to the ecosystem and to BC citizens and the economy, began to review the complexities of this question. The magnitude of the task and the relatively short-time frame (one generation of wild Pacific sockeye salmon) required strategic planning. We recognized immediately that several organizations and activities are engaged in the arena of wild salmon and duplication was not an option.

Since the inception of the Forum, members and staff have met, often several times, with over 200 individuals and groups. The context and perspective gained from these meetings helped us focus on critical issues. We appreciate the time and effort of these individuals and groups. Forum members and staff also attended more than 30 conferences and workshops and made 10 presentations designed to share our experience and to communicate the results of our work. (See Appendix 1)

In addition, the Forum has worked with over 80 researchers from a variety of research institutions, scientific disciplines and perspectives. (See Appendix 2) We hosted nine research meetings and funded over 35 individual research projects in addition to technical reviews and reports. The Forum also received extensive scientific support from the members of a multi-disciplinary Science Advisory Committee. (See Appendix 2) The engagement with the science community has been exceptionally valuable to the Forum and has benefited our research program.

All of these efforts have been focused on ensuring open, respectful dialogue among people holding diverse opinions; understanding issues, concerns and fears; learning facts from authorities; and building collaboration and consensus.

Since 2005 the Forum has used money provided to us by the Province to serve as seed funding for collaborative research projects, student research grants and technical reviews. In June 2007 the Forum issued an *Interim Report to Government*. This report was released publicly as a means to provide an update on the status of our activity and our initial findings.

The Forum's direct investment of over $2.2 million in collaborative scientific research resulted in the addition of cash and in-kind support from governments, universities, foundations and industry leading to over $5.5 million in new research in British Columbia. We developed scientific research programs based upon a collaborative and inclusive process engaging a range of research disciplines, research institutions and perspectives. Pending release in peer reviewed journals by the individual researchers, we have made public all interim research results for all research funded by the Forum.

In January 2008 the Forum issued a *Summary of 2007 Interim Key Research Findings* covering the 2007 research period. These findings were approved by the Forum's Science Advisory Committee based on the preliminary reports of the various projects. A *Summary of 2008 Interim Research Findings*, examined and approved by our Science Advisory Committee, is being released with this report. (See Appendix 3B and 3C)

The Science Advisory Committee has also submitted a science advisory, *Evaluation of the Broughton Research Program*, which is a scientific opinion on what we now know based on the interim research findings in addition to other research done on sea lice. This advisory is the foundation for the Forum's recommendations regarding aquaculture management in the Broughton Archipelago. (See Appendix 3A)

Six student research grants of $25,000 each were provided to engage future generations of researchers and develop BC's future research capacity.

The Forum invested over $250,000 to initiate several key reports to illuminate our understanding of the issues. These commissioned reports included a wild salmon threats analysis; a sea lice research review; an historical ecosystem resource report on the Broughton Archipelago; the development of sea lice research protocols and guidelines; and reviews of provincial regulations affecting both wild salmon and aquaculture. (See Appendices 4 and 5)

The Forum's research, commissioned studies and consultations have all served to inform this report.

SALMON ARE VALUABLE TO BRITISH COLUMBIA...

Wild salmon are entwined in British Columbia's history, culture and future.

Salmon have been a priority resource to First Nations for centuries. Salmon contribute to First Nations' local economies and are a dietary staple. Salmon connect water and land, serving as an important indicator of watershed and community health. Salmon must also be available for governments to meet their legal obligations to First Nations (the harvesting of

salmon for food, social and ceremonial purposes).

Wild salmon have been the backbone of BC commercial fishing and processing for more than a century, generating jobs in communities along the length of the coast and producing food for Canadians and the world. Over the last decade harvest rates and production in the commercial fishery have been significantly reduced in order to protect escapement and biodiversity. While we are unlikely to see a return to the scale of past economic activity in the commercial salmon fishery, wild salmon can and should be an important part of harvesting and processing enterprises in BC.

Just as many people consider the opportunity to eat wild BC salmon a fundamental part of life on the West Coast, so many others connect to the resource through recreational fishing in both freshwater and tidal fisheries. Salmon angling is by far the largest component of the recreational fishery, attracting both local and international participants and generating important social and economic activity throughout much of coastal and rural BC.

If there are no longer enough salmon to sustain First Nations' communities, if we are no longer able to buy wild salmon in grocery stores or restaurants, if we are no longer able to go fishing for salmon, whether for food or recreation, then we will have lost an important part of what makes us British Columbians.

Over the last two decades, salmon aquaculture has joined the wild salmon fishery and the recreational fishing sector in providing economic opportunity to many communities. While there has been very limited growth in the number of salmon farming licenses, total production of farmed salmon continues to grow, becoming the top agricultural export from BC.

While it is difficult to come up with exact numbers, salmon was the largest contributor to the $2 billion in revenues and $1 billion in GDP contributed by the capture seafood, aquaculture and tidal angling sectors in BC in 2005[2].

In recent years, the economic future of many rural and First Nations' communities has darkened as a result of reduced harvests in the wild fishery and the challenges in the forest industry. Small-scale, profitable commercial fisheries, strong recreational fishing opportunities and sustainable salmon farming can all contribute to year round employment if we are prepared to make the necessary changes to ensure that salmon have a future in our province. These changes are detailed in this report.

SALMON ARE FACING CHALLENGES...

In the immediate future wild salmon will continue to face complex challenges with significant economic, ecological and social/cultural consequences. In the longer term these challenges will be exacerbated by climate change, leading to unprecedented effects on wild salmon populations unless there is a significant change in current management practices.

Since the Forum began operation in 2005, public trust in the management of both wild salmon and farmed salmon appears to have deteriorated. As fears for wild salmon have increased, so has opposition to salmon farming as well as other marine and watershed resource-based industries (such as mining, coal bed methane exploration, run of river

power projects, Fraser River gravel extraction, etc.) that have the potential to threaten salmon resources. The scope of some of these developments, like the proposed run of river power complex in Bute Inlet, has intensified this tension.

No single human activity or industry is responsible for endangering wild salmon. We all share in the responsibility. The habitat that salmon require is the same habitat that British Columbians have used and continue to use for water, electricity, food, housing, industry and recreation. British Columbians generally have treated salmon as simply one more user of the environment, a user expected to take its place in line. All too often that place has been the end of the line.

To halt the continuation of habitat loss and increase our capacity to address future impacts resulting from climate change and other natural events in both freshwater and ocean environments, British Columbians must begin to do things differently now or there will be no wild salmon left to manage.

For many years watersheds have been managed in response to industry applications. Various resource users - forest and power generation companies, farmers, ranchers, shellfish and finfish growers, road builders, oil, gas, mining and transportation companies - have sought government licenses and permits to alter landscapes and water flows to meet their respective needs. These licenses are administered by a variety of ministries or agencies.

No single provincial agency measures the incremental and cumulative effects of all these individual decisions on watersheds, nor is government able to assess the capacity of watersheds to accommodate these demands while maintaining their ecological functioning condition. The result has been cumulative development that has drawn down the 'natural capital' of watersheds, making them less resilient to change.

Although they start and end their life in freshwater, salmon spend most of their lives at sea. It used to be assumed that the ocean was a uniformly productive environment and the largest impact on the marine survival of salmon was the scale of harvest. In recent decades this understanding has been shown to be untrue. The northern Pacific Ocean is a dynamic environment subject to short and long-term changes driven by both local influencers (such as Fraser River discharge into the Strait of Georgia) and hemispheric ones (El Nino, Aleutian lows, Pacific decadal oscillation), all of which exercise enormous influence on the survival of salmon, especially in their early months at sea. Despite unprecedented constraints on all salmon fisheries in recent years, the move to a sustained low harvesting regime along the BC coast has generally not led to the hoped-for rebuilding of stocks.

Forecasts of climate change for British Columbia provided by the Pacific Climate Impacts Consortium indicate that the natural range in variation that has remained relatively steady over the past century will shift out of this range. This will result in increased water temperatures and more frequent, extreme floods and droughts, all of which result in increased pressure on natural resources including salmon.

These shifts across whole watersheds will outstrip current attempts to restore habitat capacity on a project-by-project basis through established programs such as the provincial Living Rivers Trust. There simply will not be sufficient resources in government or conservation agencies to stem this tide of change. Institutions interested in watershed management - governments, private sector, conservation foundations, First Nations and stewardship

groups - henceforth must act in collaboration and align their resources to provide sufficient capacity to effect change.

THREATS TO WILD SALMON...

While none of the salmon species is at risk of extinction, many individual populations in British Columbia have disappeared or seem about to do so.

All species of wild salmon face multiple, simultaneous threats; predicting cumulative effects is fundamental to making decisions about where to put our resources. As documented by Dr. Brian Harvey in his report, *Nowhere to Hide – Salmon versus People in the 21st Century*, the threats to Pacific salmon are already well known. They can include: habitat alteration and loss, hatcheries, harvest, salmon farms, alien species, contaminants and the over-arching effects of climate change. The biggest problem is that these threats act together, with the 'meta-threat' of global climate a wild card capable of elevating even a minor threat into a major one. Ranking the threats in order of severity is not constructive given the way they interact to produce compound effects and unpredictable results. The most practical kind of ranking may be in terms of 'do-ability' - in other words reducing harm where we can[3].

According to Dr. Harvey, human population growth on the west coast of North America is the elephant in the room; threats to habitat are closely linked to population. Every threat, many of which date back more than a hundred years, is a result of policy choices that reflected society's priorities and core values at the time. Maintaining sustainable populations of Pacific salmon over the next hundred years will mean changing some of these core values.

Recently, a number of scientists have projected potential changes to temperature and precipitation regimes across the province. Actual changes will depend on the global level of CO^2 in the atmosphere but current projections indicate that average annual temperatures could increase between 2 and 7 degrees Celsius over the next 70 years; precipitation could decrease by up to 50% during the summer and increase by up to 25% during the winter[4]. Regional changes could well be greater than these provincial average figures. As climate change becomes a reality, maintaining sustainable populations of Pacific salmon will mean making tough choices on which stocks to protect.

In short, future salmon management will challenge some of our core economic, environmental and cultural values and will require the widespread engagement and understanding of the population. Public confidence in our governance processes will be critical to support us as we make these choices together.

AN ECOSYSTEM APPROACH...

Many scientists now believe that regional increases in water temperature will affect wild salmon in watersheds where temperatures are, at times, already close to the lethal threshold for salmon. If we are to manage the effects of climate change while using resources in watersheds to meet the economic and cultural needs of society, we must adopt a new strategy of watershed management based on ecosystem-based principles.

This new strategy will require a holistic approach to managing watersheds as ecosystems, assessing

their capacity to accommodate change, and establishing and monitoring ecosystem indicators such as temperatures, hydrological flows, riparian conditions and water quality. Decisions on resource use can then be adapted to ensure we stay within ecosystem capacities rather than exceeding them, as can now be the case in demand-driven regulatory decisions. Henceforth, ecosystem-based management of watersheds must apply to all industries that seek to use a watershed, including forestry, mining, urban development, road and transportation corridor building.

Currently all these activities are independently managed by a variety of government agencies without any thought to the overall ecological function of watersheds. This 'silo' approach may work in the short term where there are abundant supplies of water and resources and where the range of natural variation is stable. But it will lead to quicker loss of watershed function and resultant impacts on wild salmon as water becomes a limiting factor and the climate changes.

An holistic approach to managing activities that affect temperature changes will involve controlling ground water extractions, reducing extraction of surface water especially in late summer when stream flows are low and temperatures increase, maintaining riparian function and structure to provide shade and nutrients, and controlling water runoff so that water stays on the land as long as possible rather than flowing directly into streams and losing its moderating effect. At the moment, especially in southern BC in the summer and autumn, wild fish are often the victims of excessive water withdrawals under the present *Water Act* as well as conflicts between residential and commercial water users.

Key features of an ecosystem-based approach include:

- Undertaking a whole systems approach rather than considering individual components of the ecosystem
- Developing ecosystem-based indicators, monitoring and reporting on them
- Integrating ecosystem science with economic values - healthy ecosystems have value in carbon storage, provide flood protection and ensure the quality of our drinking water
- Understanding climate variability and its impacts on resource management
- Developing a governance and regulatory system that recognizes the uniqueness of each ecosystem
- Applying adaptive management approaches to reduce risk and integrate the precautionary approach into decision-making
- Integrating information systems to support watershed management

Ecosystem and habitat indicators are quantitative and qualitative measurements of habitat status. By 2010 the Integrated Land Management Bureau should establish these indicators to assess the quantity and quality of the habitat identified based on the requirements of, in this case, salmon. The indicators would then be adopted by the proposed Water and Land Agency.

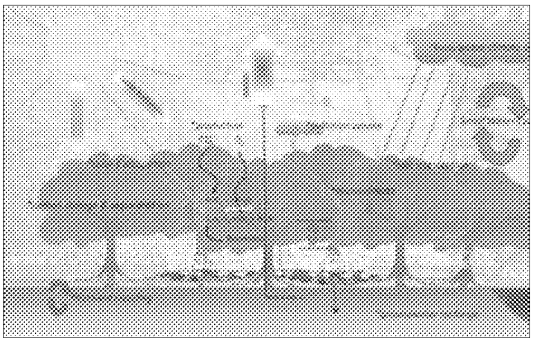
In fresh water, examples of habitat indicators include water quality, temperature, stream flow, fish and invertebrate densities as well as features such as the quantity of good quality gravel for spawning fish

Following the identification of indicators, the provincial government should develop benchmarks to reflect the desired measure of each key indicator in each area. For example, benchmarks for water temperatures could reflect optimal temperature ranges for salmon and will vary by species[5]. The next stage is monitoring which then supports the development and application of adaptive management strategies that further diminish environmental impacts from activities.

A properly functioning watershed provides a wide range of 'ecological goods and services' such as water purification, control of storm runoff, moderating temperatures in streams, and riparian function that sustains fish habitat as well as recreation and aesthetic values. None of these goods and services is priced and therefore they are given no weight in business-driven decisions. Values for ecosystem functions must be established so they are properly considered.

One of the potential values that requires more research is the opportunity for watersheds restored to properly functioning condition to store carbon and thus be a possible offset for mitigating carbon emissions.

Figure 1. Function of vegetated landscapes



The recent provincial water plan, *Living Water Smart BC*, indicated that the Province will shift to an ecosystem-based approach. The Forum strongly endorses *Living Water Smart BC* and urges the Province to vigorously pursue its targets. The plan commits to legislate water flow requirements for ecosystems and species; protect the quality and quantity of groundwater; support communities to undertake watershed planning in priority areas and ensure that 50% of new municipal water needs will be acquired through conservation. Further, there will be new approaches to water management that will address the impacts of a changing water cycle, increased drought risk and other changes caused by a changing climate. Wetland and waterway function will be protected and rehabilitated, and water and land managers will apply approaches that secure stream health and a full range of stream benefits.

Scientific understanding of changing watersheds, ocean and near-shore marine ecosystems is still in its infancy and many rivers are not adequately monitored. To advance scientific understanding we need to make significant progress on:

- Increasing monitoring of estuaries and watersheds to track changes and respond in a timely fashion
- Increasing monitoring and resources of wild fish habitat and its status
- Increasing resources for stock assessments
- Improving integration of decision-making within governments and between levels of governments with more attention to long-term impacts

- Improving understanding of ocean dynamics and their relevance to salmon production

The Forum joins other stakeholders in urging that both federal and provincial governments, together dedicate sufficient funding and resources to protect salmon populations. An ecosystem approach to maintain ecological resiliency and protect watershed functions is the only strategy to ensure the long-term survival of wild salmon.

ECOSYSTEM-BASED MANAGEMENT IN BRITISH COLUMBIA...

An ecosystem-based approach is "an adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, functioning ecosystems with human activities[6]".

Ecosystem-based management is already underway, at least in part, in various regions within British Columbia. In Clayoquot Sound, on the West Coast of Vancouver Island, and in the Central and North Coast land and resource plans, multi-stakeholder groups work in collaboration with the Province to finalize terrestrial ecosystem indicators and build them into land use plans governing all resource development activities. Fisheries and Oceans Canada has initiated the Strait of Georgia Research Initiative to understand how the ecosystem works, identify the various drivers of change, and analyze future responses. As part of its Wild Salmon Policy, Fisheries and Oceans Canada is working with a broad range of stakeholders including First Nations, government agencies and watershed planning and stewardship groups to develop indicators and benchmarks for habitat assessment.

The focus of ecosystem management is on maintaining ecological integrity and integrating it with human well-being. In this way, key indicators such as production on fish farms or annual allowable timber cuts become outputs of planning rather than inputs which is currently the case.

British Columbia's capacity to implement ecosystem-based management will require many things, including an improved understanding of how local ecosystems function, baseline data and the identification of appropriate ecosystem health indicators. Full development and application of ecosystem-based management will take some time but it is the way to go.

BEGINNING TO CHANGE...

There have been some improvements. The allocation of $21 million by the provincial government to the Living Rivers Trust Fund for watershed and habitat restoration is an excellent first step, and the recent *Living Water Smart BC* plan supports ecological management of watersheds, water conservation and makes a commitment to establishing groundwater regulations. The Integrated Land and Resource Registry records all land and water decisions, but this registry must be adapted to track decisions at a watershed level to support an ecosystem-based management approach.

The provincial government has some existing legislative and regulatory tools to apply ecosystem management principles[7]. The *Water Act* has provisions for the Minister of Environment to develop watershed management plans to establish hydrological flows to support fish and other ecosystem values and to resolve conflicts between consumptive use of surface

and ground water resources and ecological needs for fish. However, no plan has been approved and implemented in the 10 years that the legislation has been in place.

Under the *Fish Protection Act*, the Ministry of Environment can establish 'sensitive streams' where fish populations are at risk, and the water managers in the Ministry must protect flows for fish in priority over other water license applications. To date only 15 small streams have been designated sensitive and these designations were made more than a decade ago.

The Province has also established an ambitious plan to reduce carbon emissions by 33% by 2020. Some of these emissions are associated with permanent changes in land use such as conversion of forested lands to urban development or agricultural uses (a forest will store carbon, a subdivision will not). There is an emerging body of science examining the potential for forests and wetlands to act as carbon 'sinks' and offset carbon emissions. Restoring wetlands or increasing protection of old growth management areas under the *Forest and Range Practices Act* could offset carbon emissions. The Province is currently drafting a regulation to establish the conditions for supporting carbon offset projects to be funded from the BC Pacific Carbon Trust. This policy is still under development in BC but the Forum recommends that the Province fund the improvement of ecosystem resiliency in watersheds through carbon offset policies.

At the federal level, the Wild Salmon Policy sets an appropriate course of action for giving top priority to salmon conservation, supporting watershed stewardship and establishing conservation units and ecosystem indicators. This policy also supports collaborative governance.

Several watershed governance initiatives involving various levels of government and a range of interests are in early stages of development. In support of these initiatives the Province should pay urgent attention to coordinated watershed management, with a target of establishing a collaborative pilot watershed governance model by 2010.

IMPROVED DECISION-MAKING...

As we move forward it is imperative that all water and land managers understand what is required to keep streams healthy and consider the cumulative impacts of all decisions. This is very difficult to do within the current system where individual ministries and agencies make decisions that can impact a single watershed.

Ultimately ecosystem-based management will succeed only when a single provincial agency is tasked with the responsibility of making all water and land decisions. This is why the Forum recommends the establishment of a single Water and Land Agency to ensure that ecosystem health indicator thresholds are not exceeded and natural capital in watersheds is maintained. A single decision-making body will provide the accountability necessary to increase public confidence in the management of our water and land ecosystems.

RESTORATION AND ENHANCEMENT...

Enhancement of salmon is usually achieved either by the restoration of freshwater habitat or by artificially propagating fish, usually at a hatchery or in a spawning

channel. Both techniques have a long history in British Columbia.

Fish escapement level targets should be established for naturally producing systems. This information will assist in identifying watersheds that require restoration to increase resiliency to climate change. Restoration measures should be undertaken in collaboration with all sectors operating within watersheds.

With growing awareness of the sensitivity of our ecosystems and watersheds to manmade and natural impacts, increasing numbers of salmon habitat rehabilitation and restoration initiatives are being undertaken by communities, stewardship organizations and corporations, often in partnership with one another. Core funding is often provided by different levels of government although the size and stability of this essential funding vary between jurisdictions and administrations. Water stewardship initiatives recognizing the broad value of freshwater ecosystems and supporting the protection of water resources and benefiting fish habitat are in the public interest.

It is not widely understood that many salmon fisheries in BC are possible only because of hatchery fish production. As natural stock abundances decline, wild salmon resources cannot support current harvest levels to sustain the many First Nations, commercial and recreational fishing opportunities without sensible enhancement. Supported by sound science and innovation, salmon enhancement can ensure that weaker stocks are sustained and stock-specific genetic resiliency is vigorously maintained.

The demands on the Salmon Enhancement Program have grown over the past 25 years but increasing costs and aging infrastructure, combined with fixed budgets, mean it is at the point where it can no longer meet the demands upon it. While the jurisdiction for salmon enhancement has traditionally rested within Fisheries and Oceans Canada, the Province must become more engaged in this activity as contemplated by Section 3.2 of the 1997 memorandum of understanding between the federal and provincial governments called the *Canada-BC Agreement on the Management of Pacific Salmon Fishery Issues*.

Both habitat restoration and salmon enhancement programs rely on cooperation and collaboration between governments, First Nations, community volunteer organizations, corporations and others. These activities cannot be sustained, however, without commitment to increased funding by senior levels of government.

SUSTAINABLE SALMON AQUACULTURE

Salmon farming began in British Columbia more than 20 years ago. It has provided a growing opportunity to many communities seeking a diversified economic base in light of changes to traditional resource-based industries and is now a top agricultural export.

During its early years the British Columbia salmon farming industry was operated by more than 100 small, mainly family-owned, companies. Today, largely due to the high cost of doing business and the globalization of the marketplace, less than 12 firms hold finfish production licenses in BC with Marine Harvest Canada, Mainstream Canada Ltd. and Grieg Seafoods BC Ltd. dominating the industry[8]. This trend to corporate consolidation is seen throughout the seafood sector world-wide.

While there are currently 132 licensed salmon farm sites in British Columbia[9], generally no more than 80 farm sites are in production at any given time. The remaining sites are not in operation for a variety of reasons such as siting criteria or fallowing.

Salmon farms in BC are located in several areas with different ecosystems - the Sunshine Coast, the West Coast of Vancouver Island, the Discovery Islands (north and east of Campbell River), the Broughton Archipelago and the central coast around Klemtu. (See map Figure 6 on page 48)

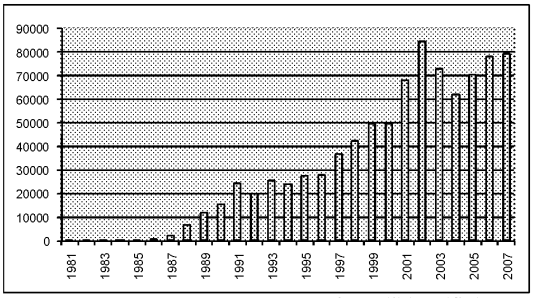
In April 1995 the Province imposed a moratorium on new tenures for salmon aquaculture and the BC Environmental Assessment Office undertook a salmon aquaculture review; the Salmon Aquaculture Review recommendations were accepted in 1997 and significant regulatory changes followed. A small number of sites experimenting with innovative technology were approved during the moratorium, and amendments to existing farm licenses were permitted, enabling farms to increase on-site production based on improved husbandry and technological advancements.

A Fish Farm Review Committee was established in January 2000 to adjudicate farm applications and identify farms that needed to be moved or change operations to meet new siting criteria. Since 2000, 15 farms have been relocated or exchanged for pilot projects or changes to species designation. In April 2002 after a new regulatory framework was developed, the Province began to accept applications for new salmon farm licenses[10]. In 2008, however, the Province announced that no applications for fish farm licenses would be accepted for sites north of Cape Caution.

Despite public perception that the industry would expand significantly when the moratorium was lifted, only 13 new marine salmon farms were approved

between 2002 and 2007. Nonetheless, total farmed salmon production increased substantially following the site moratorium imposed in 1995.

Figure 2 BC farmed salmon production 1981 - 2007 (tonnes)



Source: Ministry of Environment

Today all site applications must undergo detailed biological and environmental reviews in accordance with both provincial and federal regulations. These reviews require a significant investment of time, money and expertise. Government also has a legal obligation to consult with First Nations in advance of issuing crown land tenures and this can take considerable time. Despite these procedures, as wild salmon productivity has been reduced by habitat loss and the effects of climate change on watersheds and oceans, public concern about the potential impacts of salmon farms on wild fish has increased.

Some of this public concern has been fueled by a lack of information or by misinformation about current operational practices as well as by conflicting scientific research and scientific commentary about the impacts of fish farming on wild fish and the environment. The public also does not fully understand the current regulatory processes. Many people question whether the agencies responsible for conserving wild salmon should also be responsible for promoting and regulating the salmon farming industry.

Although many coastal and First Nations communities are seeking alternative economic and employment opportunities and the market demand for farmed salmon outweighs product availability, BC's salmon farming industry has yet to obtain the broad social license it needs if it is to be allowed to grow within ecosystem capacity.

THE SEA LICE ISSUE...

As one report put it, "The public (not the scientific) debate about sea lice is often hard to separate from the more general issue of salmon farming in BC."[11] Much of the public concern regarding salmon aquaculture has grown from the perception that sea lice generated from fish farms harm wild salmon populations.

To date there is no scientific consensus concerning the impact of sea lice on salmon populations. Some peer reviewed research supports the hypotheses that sea lice from farmed salmon significantly impact the health of wild salmon and that a single louse will cause death to a small, juvenile salmon. Other peer reviewed research contradicts these findings[12].

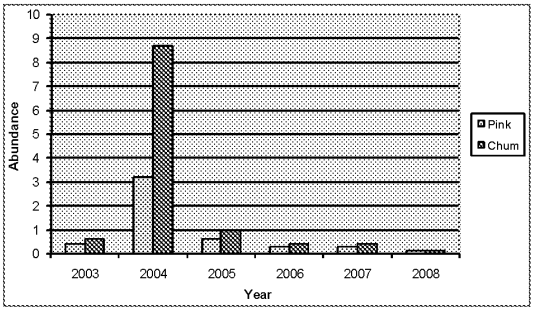
Public concern over sea lice impacts on salmon grew after pink salmon returns in the Broughton Archipelago crashed in 2002 following historically high returns. As a result a migration corridor was fallowed in 2003, but not continued in subsequent years. The same year the Province introduced a Broughton Archipelago Sea Lice Action Plan[13] which was extended to include all salmon farms in 2004.

Under the provincial Sea Lice Action Plan all salmon farms now monitor lice abundance and treat their fish with therapeutants if the trigger level of three adult lice per farmed fish is reached. All monitoring data are reported to the Ministry of Agriculture and Lands. The data are verified through an auditing process and posted regularly on the Ministry website by fish health zones, but not by individual farms. The Ministry also reports annually to the public on site-specific inspections and audits of regulatory compliance by the salmon farming industry under the Fish Health Auditing and Surveillance Program.

Over time, monitoring data have confirmed that sea lice abundance varies significantly from area-to-area and from year-to-year. Since abundance on wild salmon appeared to be highest in the Broughton Archipelago, the Forum designated it as 'ground zero' for sea lice research. This is also why the Broughton should be the starting-point for a new ecosystem approach in salmon farm management.

In general, DFO monitoring data indicate that the abundance of sea lice on juvenile wild salmon in the Broughton has been declining since 2004. Monitoring data on farmed salmon have also shown a decline since 2004[14, 15].

Figure 3 Sea lice abundance on out-migrating juvenile salmon in the Broughton Archipelago 2003-2008



Source: DFO Interim Sea Lice Monitoring Data

The Forum notes that various interests are engaged in sea lice monitoring programs in Clayoquot Sound, Nootka Sound and the Klemtu area, but the results for all of these programs are not yet publicly available.

THE BROUGHTON ARCHIPELAGO...

The topography of the Broughton varies from rugged to low relief landscapes. The Coast Range on the mainland side is very steep with high elevations. The archipelago itself is coastal and made up of 2,122 islands, islets and rocks, and many narrow passages. The small islands produce a long shoreline of approximately 1,700 kilometres including protected shores and highly exposed areas as well as channels with high tidal current velocities. There are over 36 watersheds in the Broughton and in the past many were strong contributors to wild salmon production. (See map, Figure 7 on page 49)

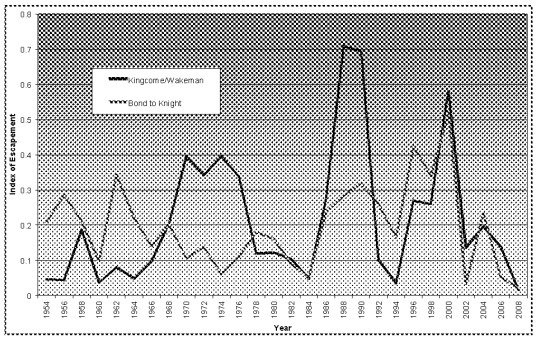
A report commissioned by the Forum, *Broughton Archipelago: A State of Knowledge*, found that this area has been impacted by human activity since 1950. The report shows that the region has been extensively logged during the last generation, contributing to significant habitat alterations that have resulted in landslides and blockages from logs, sediments and other debris.[16]

A recent report commissioned by the BC Ministry of Agriculture and Lands examined the stream systems within the Musgamagw Tsawataineuk Tribal Area and also found that habitat degradation in watersheds is

widespread. This report included most of the Broughton Archipelago, excluding Knight Inlet and the Glendale River. The report itemized habitat concerns in all of the major watersheds (Ahta, Embley, Kakweiken, Kingcome, Viner and Wakeman) in addition to five other watersheds. Habitat degradation was observed in each.[17]

Pink salmon escapement estimates in the Broughton have shown huge variability over the past 50 years, both before and after aquaculture was introduced to the area. This variability is very similar to trends in other BC pink salmon streams monitored by Fisheries and Oceans Canada[18].

Figure 4 Trend summary for Area 12 Mainland Inlet pink stock groupings 1954-2008 (even years). Note: 2008 data are still preliminary[19, 20]

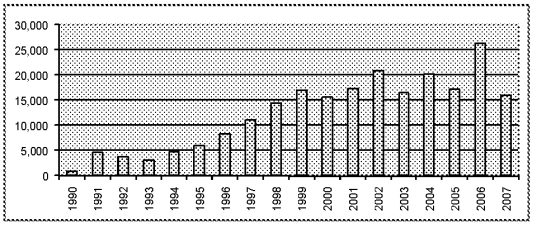


Source: Summary of 2008 Interim Research Findings, Project G.12

Information on recorded salmon returns to their natal streams in the Broughton over the past four years indicates that returns continue to be variable at the lower end of those experienced in the 50-year time series. This area was commercially fished regularly for many years, but despite the closure of commercial fisheries more than a decade ago recoveries to previous levels of abundance have failed to occur. Indeed, in 2008 pink returns were so low as to raise serious concern about returns in 2010.

The Broughton's vast and complex ecosystem contains 20 active salmon farms currently owned by two companies (excluding Grieg Seafood's Bennett Point farm). The annual average production on these farms between 1999 and 2007 was approximately 18,500 tonnes.

Figure 5 Salmon farm production in the Broughton Archipelago 1990 to 2008 (tonnes)



Source: Broughton Archipelago: A State of Knowledge

BROUGHTON RESEARCH PROGRAM...

During the first year of its mandate, the Forum became convinced that conflicting reports over the impact of sea lice on juvenile salmon were undermining public confidence in the sustainability of salmon farming.

With guidance from the Forum's Science Advisory Committee, we contributed $1.8 million to a Broughton research program, which attracted more than $3 million for a total research investment of more than $5 million. The intent of this coordinated research was to determine as clearly as possible:

1. DO SALMON FARMS CONTRIBUTE TO LICE LOADS ON WILD SALMON IN THE BROUGHTON ARCHIPELAGO?

2. IS THE SURVIVAL OF INDIVIDUAL FISH COMPROMISED DUE TO LICE LOADS?

3. DO IMPACTS OF SEA LICE FROM FARMS ON INDIVIDUAL SALMON TRANSLATE INTO IMPACTS AT THE POPULATION LEVEL AND ARE THERE FARM MANAGEMENT TECHNIQUES THAT CAN MITIGATE THE RISK TO WILD SALMON?

Over the course of our mandate we have communicated our progress toward answering these questions through both meetings and printed materials. In December 2008, we received the Science Advisory Committee responses to these questions based on research funded by the Forum and other sources.

Our research program monitored sea lice on wild pink and chum salmon throughout the Broughton to assess whether farms increased lice levels. It examined the impacts of sea lice on individual pink and chum salmon smolts both in the laboratory and in the field to determine sub-lethal and potentially lethal thresholds. It funded more detailed techniques to monitor out-migrating juvenile salmon and returning adult pink and chum salmon over two years. Our research also developed models to help understand the potential for sea lice infestation of wild fish. It also has funded the development of the Finite Volume Coastal Ocean Model, a significant new analytical tool to understand the movement of sea lice throughout the Broughton.

An ecosystem-based approach to managing the marine environment in the Broughton should consider all major factors affecting wild salmon populations, including forestry and tourism development and not just those associated with fish farming. The Forum believes that realistic risk assessment models must be developed to evaluate all activities; however, such a comprehensive approach was not possible within our short mandate. We also support allocating resources for the improvement of habitat resilience in the Broughton.

The Forum's research program is the first step toward building a collaborative ecosystem-based approach to research and to managing salmon in the Broughton. This is consistent with our recommendation that an ecosystem-based approach be used for the sustainable management of both wild and farmed salmon in BC.

INTERIM RESEARCH RESULTS...

The results of our research have established a firmer scientific base for managing salmon farming in the future not only in the Broughton but in other salmon farming areas in BC. The Science Advisory Committee response to our three key research questions is presented below. (A more detailed statement, *Evaluation of the Broughton Research Program*, is in Appendix 3A)

1. DO SALMON FARMS CONTRIBUTE TO LICE LOADS ON WILD SALMON IN THE BROUGHTON ARCHIPELAGO?

There is strong indirect evidence that salmon farms in the Broughton Archipelago, and elsewhere on the BC coast, contribute sea lice to wild juvenile pink and chum salmon. The magnitude of this effect depends on farm management measures, which have been increasingly adapted to reduce lice levels on farms over the past four years. Evidence of increased lice around farms is also apparent from the difference in

numbers of planktonic lice stages found near to and distant from farms.

2. IS THE SURVIVAL OF INDIVIDUAL FISH COMPROMISED DUE TO LICE LOADS?

Studies in the laboratory and in field enclosures provide clear evidence of lethal and sub-lethal effects of sea lice on individual juvenile pink salmon, but the effects are strongly dependent on the size of the fish, the developmental stage of the louse, and the number of lice on the fish. There is a consensus amongst laboratory studies that fish 0.5 gram or less are more susceptible to sea lice and this susceptibility decreases as fish grow.

3. DO IMPACTS OF SEA LICE FROM FARMS ON INDIVIDUAL SALMON TRANSLATE INTO IMPACTS AT THE POPULATION LEVEL AND ARE THERE FARM MANAGEMENT TECHNIQUES THAT CAN MITIGATE THE RISK TO WILD SALMON?

Laboratory studies indicate that lice have an effect on individual juvenile pink salmon but it is difficult to extrapolate these data to a population level. Evidence suggests that salmon farm-based sea lice production and/or environmental factors can affect salmon population sizes. Population level effects can be measured as the numbers of returning adults to coastal waters in relation to the numbers of adults spawning in the previous generation. This is the net result of numerous factors through a species' life cycle and need not be determined solely by changes in juvenile mortality. Management practices have been successful in reducing sea lice on the farms and are likely associated with the reduction in levels of sea lice on nearby wild salmon.

Based on the Science Advisory Committee's advice and consistent with an ecosystem-based management approach, the Forum recommends the following measures to manage sea lice in the Broughton by all companies:

- No more than 3% of juvenile wild pink and chum salmon of less than 0.5 grams should have more than one pre-adult or later stage *L. salmonis* between March 1 and May 31, based on the estimated natural background of lice in the Broughton
- All companies must strictly adhere to the coordinated area management plan in the Broughton for 2009 to minimize any incremental risk associated with sea lice contributed by salmon farming
- The coordinated area management plan together with a scientifically supportable monitoring program of sea lice on both farmed and wild fish must be continued for at least the next five years with an evaluation using the Finite Volume Coastal Ocean Model
- A limit on annual production initially to 18,500 tonnes of farmed fish in the Broughton (the average annual production between 1999 and 2007) as a precautionary approach to protecting wild salmon returns
- This production limit can be adjusted based on an independent review of the interim research results, evaluation of the 2009 coordinated management plan, evaluation of individual farm sites based on the Finite Volume Ocean Coastal Model and other research recommended by the Forum
- The Forum urges all relevant parties to work together to allow the implementation of the coordinated

production management approach and the scientific evaluation to extend from 2009 to 2014.

Strict adherence to the proposed coordinated area production plan for 2009 in the Broughton should result in less risk to wild fish populations due to lice infestations. For instance, at 2008 production levels, farm operations achieved the recommended thresholds for lice prevalence and intensity.

Over the coming months the research conducted in 2008 will be finalized with reports prepared by individual researchers for publication through the peer review process. This process can often take over a year to complete. We are therefore recommending an independent review of the key findings that we have used to establish the environmental thresholds noted above to provide added confidence.

SEA LICE MODELING...

To add some clarity to the scientific debate regarding the impact of sea lice from fish farms on wild salmon and to gain a clearer picture of the complex dynamics of the Broughton ecosystem, the Forum worked with researchers from Fisheries and Oceans Canada's Institute of Ocean Sciences on the development of a new dynamic oceanographic model that includes tides, river runoff and wind.

The result, the Finite Volume Coastal Ocean Model, incorporates the data obtained by other researchers studying sea lice mobility, abundance and intensity of lice on wild salmon, on-farm lice monitoring data and temperature and salinity data. This dynamic model can estimate sea lice egg production on farms. It can also track and provide projections of lice movements from farms into the environment and can compare these with lice populations measured on wild fish.

The Finite Volume Coastal Ocean Model for 2008's environmental and biological data includes three distinct time periods covering early smolt migration to end of season migration (March 13 to June 27). Further technical assessments to verify the preliminary data will be conducted during the spring of 2009 and completed by the fall at which time a final analysis will be made public.

The Forum is also engaged with a team of researchers led by Dr. Martin Krkosek who developed a mathematical model based on transmission of infective parasites. Research using this mathematical model, published in peer reviewed literature, originally assumed that the population of lice on farms was in a steady state (i.e. they remained constant over time) regardless of farm management. With funding provided by the Forum from 2006 through 2008, these researchers tested the hypothesis that SLICE™ decreased lice populations on farmed fish and thus reduced the risk of lice transfer to wild salmon. As a result of this new information the model is being calibrated to reflect the results of adaptive measures undertaken by farms in reducing the lice abundance in the Broughton since 2006.

The Finite Volume Coastal Ocean Model should be used to provide federal and provincial regulators with the capacity to evaluate the performance of existing and potential new farm sites in this area. It can also provide important information for updating the regulatory requirements for farms in the Broughton and for consultation with First Nations and other stakeholders.

COORDINATED AREA-BASED PRODUCTION MANAGEMENT APPROACH...

A coordinated area-based approach to salmon farm management in the Broughton Archipelago will test the effectiveness of requiring each of the two main migration routes for juvenile wild salmon to be free of farmed fish in alternating years. In the year where farmed fish are present, they would be treated with SLICE™ to reduce lice population in the out-migration period, March to May, to close to zero. These two main migratory channels are known as the Tribune Channel/Fyfe Sound and Knight Inlet. (See map Figure 7 on page 49)

The two companies operating in this area have committed to initiating this approach in the spring of 2009, but without amendments to existing licenses this program cannot continue in 2010.

The Finite Volume Coastal Ocean Model can be used to analyze the proposed plan to test the effectiveness of this model or other options for managing sea lice on farms. These scenarios can be run in early 2009 and tested against real data later in the year.

Such a strategy would reduce lice populations on farms to near zero during the out-migration period, thus providing the basis for a consistent, responsible risk management approach for the next five years. Continuing a monitoring program for lice on wild fish will determine whether, under a range of environmental variables such as water temperature and salinity, lice populations and prevalence remain at or below the recommended thresholds during the March to May out-migration period.

In order to build on current momentum, the Forum urges all relevant parties to work together to resolve outstanding issues to allow the implementation of the coordinated production management approach and the scientific evaluation to continue.

Implementation of a coordinated area management plan will enhance the benefits of both pest management and disease management to reduce possible risk to wild salmon. This includes the principle that only single year class fish are grown on any given site.

The proposed coordinated area management plan for the Broughton Archipelago should also be used as a prototype for an area-based approach in other areas of BC. Improved salmon farm management using an area-based approach has been implemented in other jurisdictions where salmon farming is conducted. In Scotland, eastern Canada and Maine, bay management strategies and various forms of area agreements involving cooperation between companies, special interest groups and governments are used in managing aquaculture.

REGULATORY REGIME...

All human activity has risk. A regulatory regime provides the framework to manage risk based on sound science, continuously improved management practices and best available technology. In evaluating risk, the salmon aquaculture industry should be held to the same level of scrutiny as other users of the marine resource. The precautionary approach as defined in the federal Wild Salmon Policy ("advice provided in situations of high scientific uncertainty... is intended to promote actions that would result in

low probability of harm that is serious or difficult to reverse") should guide decision-making approaches to risk management.

With this guideline in mind, the Forum undertook a detailed review of the past and current regulatory regimes. (See *A Review of Finfish Aquaculture Regulation*, Appendix 5)

Since 2000, BC's regulatory regime for salmon aquaculture has improved significantly. Over this period regulators and industry have demonstrated their ability to take an adaptive management approach as new issues, research and technology have emerged. This has been clearly demonstrated in changes in regulations for fish health and waste management.[21]

The Forum recommends that the current provincial regulations be amended to reflect the results of the research on sea lice management in the Broughton, including the development and application of the Finite Volume Coastal Ocean Model, the area-based approach to farm management and the establishment of appropriate thresholds for sea lice prevalence and intensity on wild salmon in the out-migration period.

Current regulations must also be amended so that appropriate thresholds for sea lice prevalence and intensity are established for all salmon farming regions in the Province during the out-migration period. Until this information is known, salmon production outside the Broughton should be subject to a conditional limit based on the production average between 1999 and 2007 (or appropriate historical average) until it can be demonstrated that these environmental thresholds can be met.

Monitoring programs are currently underway in Clayoquot Sound, Nootka Sound and the Klemtu area and these results, when available, should be used to inform this process.

Other ecosystem indicators, including baseline sea lice abundance and assessment of migratory patterns for out-migrating juvenile salmon, must also be collected and evaluated as part of the approval process for siting and licensing new salmon farms, ensuring that BC's aquaculture industry produces products that meet the highest standards of health and safety and that operations have minimal environmental impact.

FARM MANAGEMENT...

For the past several years in the Broughton, Marine Harvest and Mainstream have based farm production management around the timing of the out-migration of wild salmon smolts. Production management adjustments have included the timing of harvest, the introduction of new stock and the application of SLICE™ to treat farm stock for sea lice.

Currently SLICE™ is the only lice treatment available to BC's salmon farming industry. The implementation of the provincial Sea Lice Management Strategy (2003/2004) made it mandatory for all farms to treat their stock if on-farm lice levels reach three adult lice per fish. The application of SLICE™ increased in 2005, reaching 0.263 grams per metric tonne of salmon produced but has been declining since. The quantity used in 2007 was 0.200 grams per metric tonne; in 2008 it was down to 0.136 grams per metric tonne.

Resistance by sea lice to SLICE™ has not been indicated in British Columbia, largely due to the small amounts of the drug used and because it is generally only applied once in a production cycle.

The Forum supports the implementation of an area-based integrated pest management (IPM) strategy to optimize treatments and respond to concerns regarding the continuing use of SLICE™ to control lice populations on farmed fish. A fully operational integrated approach will provide for the use of other treatment options to further mitigate any risk of resistance to SLICE™. IPM principles include: avoiding unnecessary use of anti-sea lice agents; growing only one year-class of fish at a time at any given site; fallowing between production cycles; synchronization of control strategies on an area-wide basis, rotating the use of chemotherapeutants with different modes of action; and monitoring the efficacy of treatments to provide early warning of resistance.

Implementation of area-based integrated pest and disease management is consistent with an ecosystem-based approach to wild species and could provide financial advantages for salmon farming companies.

SLICE™ is fully licensed in Norway, the United Kingdom and Chile but not Canada. These countries also have access to several other treatment options and several more in trial or in development. None of these is available in Canada. SLICE™ has been under review by Health Canada's Veterinary Drug Directorate for more than seven years. Its use by aquatic veterinarians is only authorized through an emergency drug release. Extensive use of emergency drug releases has diminished transparency of the veterinary drug review process, stifled innovation within the Canadian aquaculture industry and reduced public confidence.

We therefore recommend that federal authorities employ a transparent and timely process for the review and licensing of veterinary drug products including SLICE™. We also propose that the Province practice a transparent and timely process for the review and protocol approvals for non-drug treatment options for the management of disease and parasites. The Canadian salmon farming industry must have access to a variety of options for both disease and pest management, and it is unacceptable that both federal and provincial authorities continue to delay approval processes. These delays are a disservice to the industry, putting the BC industry at a competitive disadvantage in the global marketplace and increasing the risk to wild salmon.

The Forum has funded research into the potential uptake of SLICE™ in non-target species, in the water and sediment. Due to complications in gaining agreement on research methodology and finding suitable field sites, this research will not be complete until the spring of 2009. Results from this work will be included in the final technical report issued in the fall of 2009.

A new approach to aquaculture called 'polyculture' - an integrated, multi-trophic approach to aquaculture - is now being tested and may provide another option for farm management. In polyculture, finfish such as salmon are grown together with shellfish such as mussels, scallops and oysters and plants such as kelp. The organic waste from one aquaculture species becomes a resource for another.

In Atlantic Canada, polyculture has now passed beyond the research stage and seafood from this system is being sold commercially. In British Columbia polyculture is still in the research stage with a pilot project underway in Kyuquot. Commercialization of polyculture will require changes in current regulations, particularly distance requirements between shellfish and finfish growing areas. Since polyculture could contribute to maintaining ecological balance within aquaculture sites, further research and development deserves to be supported.

IMPROVED TECHNOLOGY...

Improvements in technology can reduce risk to the environment. New technology in the salmon farming industry has already improved feed conversion ratios, enabled better feeding systems, reduced fish waste impact, and developed better net pens and predator controls.

Closed containment describes a range of technologies using structures in water or on land to attempt to restrict and control interactions between farmed fish and the external environment. In BC, some groups, including the Legislature's Special Committee on Sustainable Aquaculture, have called for the rapid application of closed containment technology for salmon farming.

Closed containment has both promise and some major challenges, including CO^2 build up, waste management, efficient siting, installation, and energy requirements. While it is true that technology with the potential for application to salmon farming is being developed, there is no commercial-scale closed containment salmon farm growing adult salmon operating anywhere in the world.[22] The Forum has no information at this time that shows closed containment is a practical option.

In 2007 the Canadian Science Advisory Secretariat (CSAS) engaged a multi-sector panel in an international review of closed containment technology. In a review of more than 40 closed containment systems from around the world, CSAS reported that none was successful in producing adult salmon at a commercial level. The report identified more than 20 research recommendations for research on additional technology development or testing; fish culture, health and welfare, economics; waste, and other environmental effects/outputs/inputs.[23]

To be fully effective, a closed containment system must be based on land and use re-circulated water systems so that water transfers in or out of the farm are filtered. Technology for land-based recirculation using fresh water does exist, but it has not yet been proven viable for the commercial-scale production of adult salmon.

Flow-through systems are not truly closed. Although flow-through systems allow water to be coarsely filtered at the intake point, they do not prevent unfiltered water from flowing in and out of the containment tank. Therefore they cannot guarantee that pathogens or sea lice will not be transferred from wild to farmed salmon or vice versa. An attempt to grow chinook salmon in a solid-wall flow-through system outside of Campbell River has yet to demonstrate commercial viability.

There is a high degree of misinformation about closed containment. Not only is the technology un-

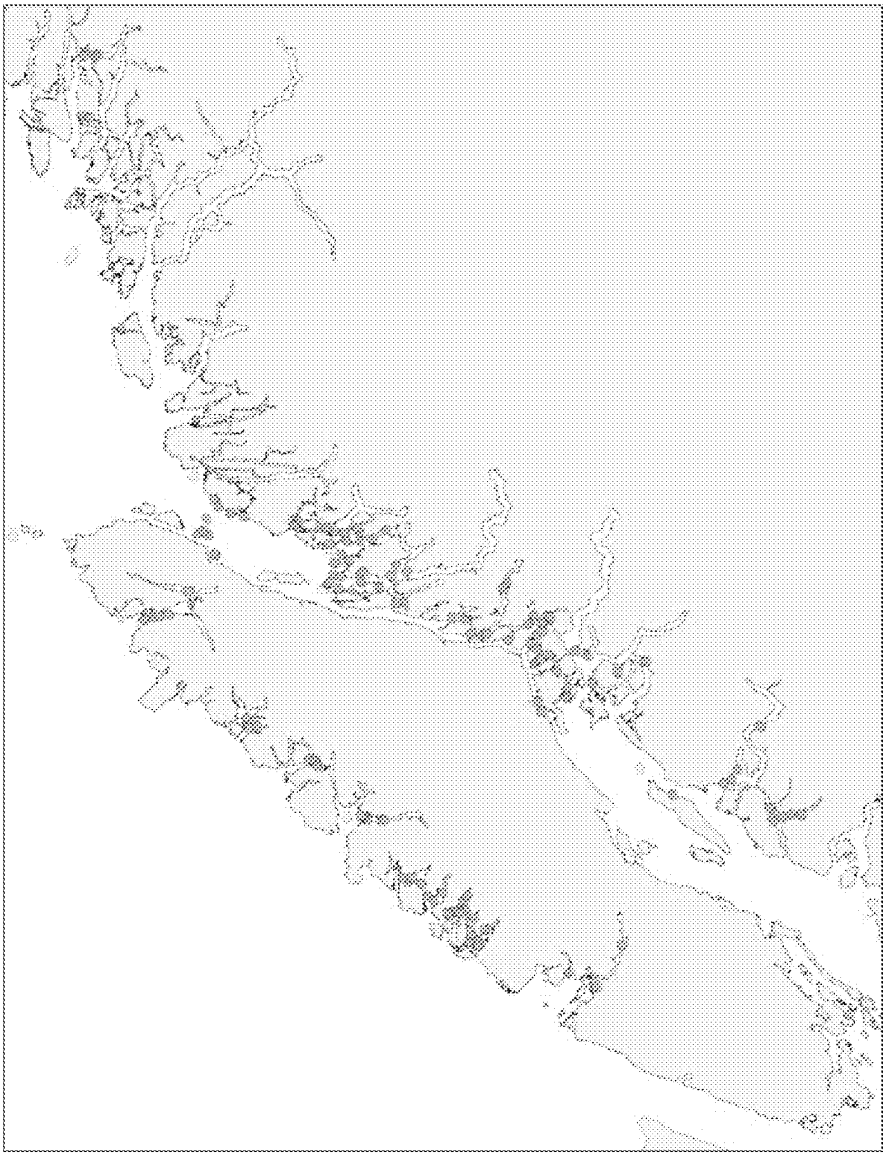
proven on a commercial scale, but a complete transition to closed containment would require moving farmed salmon production from rural coastal communities to more urban areas where reliable sources of hydroelectric power are available.

In the interest of resolving the closed containment debate, the Forum believes that it is in the public interest for the Province to immediately appoint an independent technical committee to recommend specifications for a commercial-scale, closed containment, recirculation, demonstration project for salmon aquaculture. The system should ensure that wastes are recovered and the risk of disease and lice transfer to the natural environment is reduced to achieve ecosystem-based indicators. The specifications should be completed in 2009.

Once there is agreement on the technical parameters for a commercial-scale demonstration project with reasonable potential for success, both federal and provincial authorities, together with industry and the conservation sector, should support moving toward trial. The Province should then issue a request for proposals to procure final design, construction and operation of a closed containment project in accordance with best management practices.

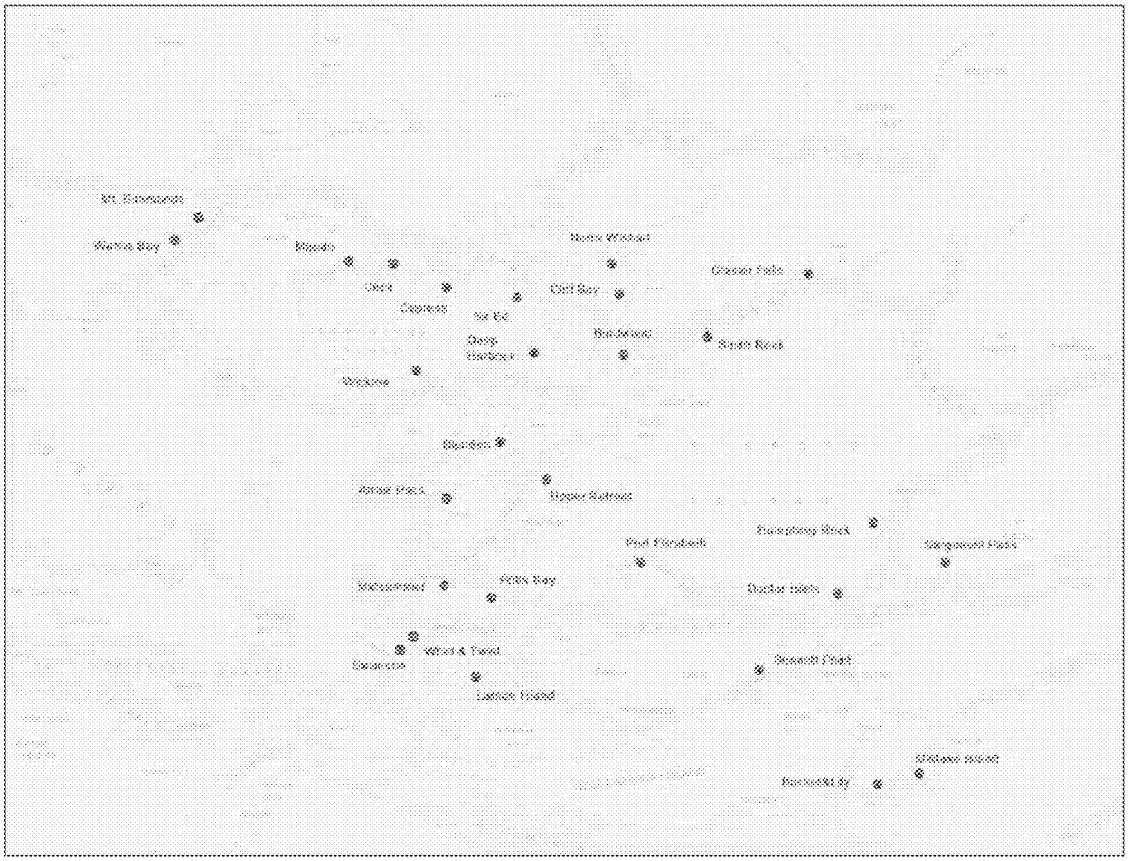
This process must be transparent, with the public kept fully informed throughout.

Figure 6 Licensed salmon farm sites in British Columbia



Source: Ministry of Agriculture and Lands

Figure 7 Licensed salmon farming sites in the Broughton Archipelago



Source: Ministry of Agriculture and Lands

BUILDING PUBLIC TRUST

Today in many watersheds across the Province, wild salmon are declining and growth in salmon farming has stalled due to uncertainty over its impact on wild fish and the environment. The recommendations made by the Forum in this report are designed to improve public confidence that wild salmon will survive and thrive in British Columbia and that salmon farming is seen as a legitimate user of the marine environment, compatible with healthy wild salmon populations.

Our ecosystem-based management recommendations will strengthen watersheds for salmon and make them more resilient to climate change and human use. Governance recommendations will ensure that all water and land use decisions are made efficiently and effectively, by a single agency. Salmon aquaculture recommendations will establish key indicators of ecosystem health, ensuring that salmon farms are managed in a coordinated area approach that protects those indicators. Our recommendations on public confidence will increase public trust that difficult choices are being made sensibly and openly using the best possible information.

The most important catalyst for major reform of salmon governance is and must be climate change. Climate change is altering the food regime of the North Pacific Ocean, where British Columbia's salmon spend most of their lives. It causes temperature to rise in salmon spawning streams. It changes rainfall and snowfall patterns and the spring freshet throughout the Province. Above all it has contributed to the pine beetle epidemic which has swept though BC's interior, devastating tens of thousands of hectares of forests.

Dead and dying forests raise soil temperature, releasing carbon into the atmosphere and intensifying climate warming. These forests can no longer retain rainfall and snowfall and filter them into groundwater, increasing erosion of stream banks and smothering salmon spawning beds with silt. Healthy, functioning ecosystems are essential to enable our watersheds and coastal areas to cushion the impact of climate change. But many of these ecosystems have been damaged by industrial activity and human settlement, making them less resilient than they once were.

In the short term we can invest in habitat restoration to buffer our coastal ecosystems. Well-designed projects can increase escapements to streams and support ecological function dependent on this biomass. Such projects are necessary to maintain salmon populations in watersheds with diminished natural capacity.

In the longer term, the recommended shift to ecosystem-based management of watersheds and marine systems will help sustain resilience needed to adapt to climate change. But the magnitude of change will still have severe implications for wild salmon populations across BC. The government and the public will have difficult choices to make in the future. It may not be possible to sustain all stocks in all watersheds and maintain an economic base for communities at the same time. Governments will have to engage the public in making these choices and build trust that such decisions will be in the long-term public interest.

PUBLIC PERCEPTION...

The Forum's work over the past four years has told us that British Columbians are deeply skeptical that wild and farmed salmon are well-managed. They worry that farmed fish kill wild salmon, that wild salmon are declining coast-wide, that industrial and urban development is ravaging watersheds while government is incapable of acting.

This skepticism has been fed by long-standing criticism of Fisheries and Oceans Canada's management of wild salmon, concern over wild salmon returns and access to the fishery, the expansion of salmon farming, watershed development, uncertainty over First Nations' rights, and by public cynicism towards government. It has been complicated by conflicting science, sensational media reports and the lack of any open process to set priorities. Many people have begun to fear that the fight to save wild salmon is too big, too difficult and too overwhelming – that nothing can be done.

Our recommendations, like salmon themselves, begin in the watersheds of BC. They are designed to transform the way provincial decisions about water use and development are made. They provide for oversight and set up a check on decision-making. They propose ways to ensure collaborative science and research inform decisions and regulations as well as ways to increase public access to information and to improve communication and cooperation.

If we are to renew public confidence in our governance of salmon, then we need radical change in public policy. We also need to engage British Columbians in a broader examination of how many diverse factors - climate change, policy, government structures and processes - come together to impact not just salmon but people.

GOVERNANCE...

Watersheds operate as ecological systems - governments do not. This is why significant changes in governance towards an ecosystem-based approach are necessary.

At the provincial level we have called for a single Water and Land Agency to make all water and land decisions in watersheds and in the marine environment. Such an agency will be able to ensure that cumulative effects of multiple decisions do not exceed established ecosystem health thresholds. It will also optimize human and financial resources at the provincial level.

Federal and provincial governments no longer have the capacity to meet the governance challenges alone. Collaborative governance approaches are beginning in a variety of watersheds through stewardship groups, water use planning, aquatic management

boards and the like. However, a more purposeful approach to collaborative governance is required with the committed support of regulators at the provincial and federal level, First Nation governments, local governments and also resource users.

The Forum recommends that all levels of government support collaborative pilot projects in watersheds to establish common principles and practical procedures. We recognize that each area is unique and we are not, therefore, prescribing where these pilots should take place. It is, however, essential that First Nations are key participants in light of their constitutional rights and the direction of the Province's New Relationship.

OVERSIGHT...

To increase public confidence, we recommend a new Regulatory Oversight Authority be established to audit the regulatory process and report independently to the public that regulators are making decisions based on ecosystem thresholds and that industries are operating within those limits.

The Regulatory Oversight Authority should work closely with all levels of government that regulate users in watersheds and marine systems. This authority should have the capacity to override decisions made by provincial ministries and agencies when they conflict with ecosystem thresholds. For example the Regulatory Oversight Authority could audit and override decisions about gravel removal, coal bed methane production, or farmed salmon production that cumulatively exceed carrying capacities in watersheds. It would have the capacity to encourage all levels of government to work collaboratively.

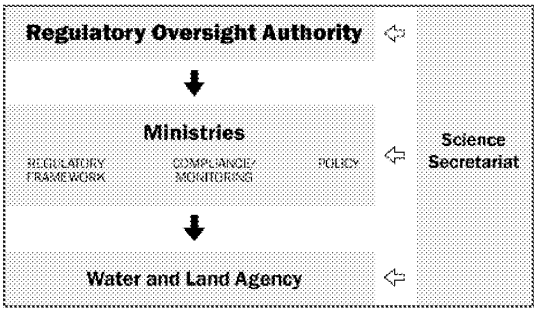
The Regulatory Oversight Authority would report to the public through the Legislature.

There are three options for establishing this oversight authority: creation of an entirely new body, the appointment of an independent commissioner, or the transformation of an existing agency to take on these responsibilities.

Two existing organizations could be transformed to include this additional mandate. One is the Forest and Range Practices Board, which currently oversees and monitors government and resource sector decisions under the Forest and Range Practices legislation, regulations and guidebooks. Its scope could be broadened.

The other option is to broaden the current mandate of the Living Rivers Trust. The Trust was founded in 2004 to provide funding for watershed protection and restoration, increase public awareness of conservation and sustainable use of water, manage and restore stream flows for fisheries and other ecological resources in watersheds, and implement fish recovery plans. The Trust has successfully partnered with other funding agencies to achieve these goals.

Figure 5 Recommended governance structure



One of the tasks of the authority should be to audit government performance in response to the Forum's recommendations and the policies set out in *Living Water Smart BC*. The recommendations in this report and *Living Water Smart BC* require transformative change in governance. The Regulatory Oversight Authority will ensure this change occurs.

CERTIFICATION...

Third party certification will reassure the public that both the commercial and farmed salmon sectors are meeting rigorous environmental standards and complying with regulations. Commercial salmon fisheries have begun a certification process through the Marine Stewardship Council to demonstrate their sustainability and identify steps for improvement.

There are currently several certification programs under development for salmon aquaculture by the World Wildlife Fund, Global Aquaculture Alliance and the Aboriginal Aquaculture Association, to name only three. Certification for BC's farmed salmon sector will ensure risk to wild salmon is reduced and environmental integrity and animal health are maintained.

CONSULTATION, COLLABORATION, COMMUNICATION...

Effective government-to-government relationships with First Nations are essential and the provincial government and BC First Nations are working together to develop a New Relationship founded on respect and recognition of Aboriginal rights and title.

The Province has a legal obligation to consult with First Nations as well as other obligations entrenched in treaties and other agreements. There is no agreed guideline, however, to use when consultation triggered by water and land use encroaches into areas of rights and title. A constructive process needs to be established to address this impasse.

Consultation can also put an onerous burden on many BC First Nations who lack the capacity for full engagement, especially when there is more than one consultation in progress at a given time. Support for First Nations to build capacity is essential to fully engage them in the management of the resources within their traditional territories.

Without attention to these issues, timely licensing or license amendments for all resource-based industries will be delayed. Not only will delay impact economic development, it will impair the ability of companies to implement adaptive management measures to benefit habitat and/or wild salmon.

To speed up the consultation process, the provincial government recently established a coordinated consultation process with First Nations on license and permit applications. The province has also piloted an approach with the Nanwakolas Tribal Council to have a 'single window' for all referrals for First Nations consultation.

First Nations' knowledge and expertise should be utilized in establishing habitat and ecosystem indicators and First Nations should be engaged in the ecosystem-based management of the resource industries within their traditional territories, including the marine systems. Protocol agreements should be in place with local First Nations and resource companies to ensure ecosystem monitoring programs are undertaken.

Too often there is little collaboration between interest groups and/or resource sectors in finding solutions to issues. Delays in consultation processes and lack of collaboration often lead to delays in action by governments and regulators which in turn further undermine BC's capacity to generate new economic development opportunities or respond in a timely way to adaptive management options. This fuels the perception that governments lack the capacity to manage or regulate resource sectors.

Consultation, collaboration and communication are essential to building public trust. Without public trust, it will be difficult to integrate new industries into areas where they have not existed in the past. In support of this, the Province must ensure industries share all pertinent information with British Columbians in keeping with their use of a public resource. Examples include site-specific sea lice monitoring information and water quality testing results from mining operations.

In addition, the Province must create processes and structures that involve stakeholders, encouraging them to work together and to use the results of ecosystem-based science to inform discussions and decisions. We believe the recommended governance structures will give the public confidence that watersheds and the marine environment are being managed on an ecosystem basis and that cumulative impacts are fully and transparently monitored and that adaptive management strategies are practiced.

The application of these principles has particular relevance on British Columbia's North Coast, where opposition to salmon farms and other resource based industries is deep-seated. An important first step will be to engage the public in a discussion of the findings of this report, as well as future salmon-related research.

Improvements have been made to provincial and federal databases to provide more integrated information for a variety of users and regulators. The recommended shift to an ecosystem-based approach to managing watersheds and marine systems will require further database improvement to ensure all users have access to accurate information.

Governments must also be timely in public reporting on all regulatory reviews, inspections and audits conducted on resource industries. Public confidence in regulatory processes cannot be increased without transparency and effective communication.

SCIENCE TO INFORM...

While we need transformative change in public policy and administration of watersheds and marine areas, we also need transformation in the way we identify needed scientific research, in the way that this research is carried out, and in the way that scientists, journalists, and stakeholders communicate about science and debate in the public arena.

Too much public debate has been carried out at the level of sloganeering, finger-pointing and the scoring of debating points. Far too little attention has been paid to the ways in which all stakeholders must share some collective responsibility for the health of our wild salmon populations.

Public distrust of the management of both wild and farmed salmon has been exacerbated by the publication of scientific papers and associated media

reports making conflicting claims concerning the possible effects of salmon farming on wild salmon. Some of the science, whether funded by industry or conservation foundations, is perceived as biased. Industry is distrustful of the findings of research originating from environmental groups while those groups have been distrustful of studies carried out by scientists connected to government or business. Too little science has been seen as agenda-free.[24, 25]

Too often media over-publicize sensational research findings and ignore findings that are complex or uncontroversial. Since most people get their information from the media, often only polarized views are heard.

A collaborative and coordinated research agenda is necessary to build the capacity to inform risk assessments and decision-making. Research requires stable and on-going funding from both levels of government, from industry and from the conservation sector and should be supported through a Science Secretariat.

With the guidance of our Science Advisory Committee, the Forum provided an important first step in funding and coordinating independent research that engaged a range of scientists, some of whose research conflicted with that of their peers. The Forum believes that such differences of opinion are healthy and led to a more robust research program. The engagement of scientists with differing perspectives must be continued. This is why we are recommending a Science Secretariat.

This secretariat can be a small group facilitating research based on advice from a variety of disciplines, perspectives and BC institutions. The secretariat's mandate would be to coordinate collaborative research necessary to support an ecosystem-based approach to the management of the marine and freshwater environment and link BC's research with international work.

The Science Secretariat would also play an important leadership role in ensuring that future research findings are communicated consistently to the public in plain language. The wall of jargon and complexity that separates the public from the scientists must be breached. The Science Secretariat should be supported in this public information and education role by both federal and provincial regulators and by scientists. The public simply must be provided with a steady flow of accurate and understandable information about watersheds and the marine environment.

The first responsibility of the Science Secretariat should be to facilitate an independent review of the interim research funded by the BC Pacific Salmon Forum, as well as to finalize the research being concluded in the spring of 2009 and report publicly by the fall of 2009. In addition it should consider research topics proposed in the Science Advisory Committee's *Evaluation of the Broughton Research Program* found in Appendix 3A. Other research topics could include research on the effects of sea lice on juvenile coho, chinook and sockeye salmon, the development of risk assessment models, research on how salmon survival is impacted by changing conditions in the Pacific Ocean, and the evaluation of environmental impacts from industrial activity such as use of nighttime lights on salmon farms.

The Forum's research should not languish with the conclusion of its mandate in March 2009.

GOING FORWARD

If British Columbia is to move toward sustainable salmon populations, we hope that this report, and the work of the Forum over the past four years, will be treated as only 'the end of the beginning'. There are hard choices ahead and much work to be done.

The recommendations of the Forum require immediate and longer term action for their effective implementation.

SHORT-TERM: JANUARY TO SEPTEMBER 2009

FORUM RESPONSIBILITIES

- Undertake a consultation program in January/February to engage a range of interested parties in regions of the Province with Pacific salmon to ensure that the Forum's conclusions and recommendations are understood and assessed

FORUM/PROVINCIAL GOVERNMENT RESPONSIBILITIES

- Facilitate monitoring and modeling proposed for the Broughton Archipelago between January and June
- Facilitate an independent review of the key research findings by September, including environmental thresholds for the Broughton based on the research undertaken in 2007/2008 and the additional monitoring in 2009
- Confirm ecosystem-based indicators for sea lice on wild salmon in the Broughton Archipelago and the farmed salmon production limits to ensure sea lice indicators can be achieved

PROVINCIAL GOVERNMENT RESPONSIBILITIES

- Establish a new governance system for an ecosystem-based approach to manage watersheds and marine systems, including the intent to establish a single Water and Land Agency for making decisions and an independent Regulatory Oversight Authority to ensure government agencies are held accountable for implementing a shift to ecosystem-based management
- Establish a Science Secretariat to coordinate long-term monitoring in the Broughton and other priority research recommended by the Forum
- Approve a long-term coordinated area management plan for farm operations in the Broughton Archipelago and complete administrative adjustments to farm licenses to ensure the plan's long-term viability
- Establish a technical panel to prepare specifications for a closed containment commercial demonstration project in conjunction with the federal government, industry and other interested parties

SALMON FARMING INDUSTRY RESPONSIBILITIES

- Strictly implement the coordinated area management plan during 2009 in the Broughton Archipelago
- Support the development and implementation of an ongoing monitoring program to evaluate the effectiveness of the coordinated area management plan in reducing lice on wild salmon
- By the end of 2009, complete and report publicly on lice monitoring programs in other farming areas of BC

LONG-TERM: 2010 TO 2012

PROVINCIAL GOVERNMENT RESPONSIBILITIES

- Establish one or two collaborative governance pilot programs to encourage watershed management based on ecosystem principles (2010)
- Establish a Water and Land Agency to make all decisions in watersheds and marine areas (2012)
- Establish a practical set of ecosystem indicators for watersheds and marine areas (2012)
- Amend provincial regulations to incorporate responsibilities for risk managing lice levels on wild fish together with appropriate limits on farm production (2012)
- Design, build and operate a land-based closed containment demonstration pilot project (2012)

PROVINCIAL GOVERNMENT AND THE SALMON FARMING INDUSTRY

- Establish area management programs for all operating areas (2010)
- Adopt integrated pest management and integrated disease management approaches to salmon farming with new treatment options available for sea lice treatment (2010)

FEDERAL AND PROVINCIAL GOVERNMENT

- Implement a joint program to strengthen and support habitat restoration and enhancement programs to maintain, rebuild and restore natural diversity in wild salmon stocks (2010)

GLOSSARY OF TERMS

Age-class: The brood year (year the fish was born) or the salt-water entry year that defines a cohort of fish (same as year class).

Anadromous: Fish species that return to their spawning rivers from the ocean at certain seasons to breed in fresh water.

Aquaculture: The farming of fish, shellfish and aquatic plants in fresh or salt water.

Biodiversity or biological diversity: A full range of variety and variability within and among living organisms and the ecological complexes in which they occur, encompassing diversity at the ecosystem, community, species, and genetic levels and the interaction of these components.

Brood year: The calendar year when the fish were born.

Conservation: The protection, maintenance, and rehabilitation of genetic diversity, species and ecosystems to sustain biodiversity and the continuance of evolutionary and natural processes.

Containment: Measures and protocols applied to limit contact of genetically modified organisms or pathogens with the external environment.

Ecological goods and services: Watershed values including water purification, control of storm runoff, moderating temperatures in streams and riparian function, fish habitat, recreation and aesthetic values.

(Fish) culture: Cultivation of fish from broodstock. In salmonid enhancement and ocean ranching, the fish are released from the hatchery. In salmon farming, the fish remain in captivity through their whole life cycle.

Ecosystem: A community of organisms and their physical environment interacting as an ecological unit.

Enhancement: The application of biological and technical knowledge and capabilities to increase the productivity of fish stocks. For the purposes of this report it is achieved by using fish culture techniques (e.g. hatcheries, spawning channels). Enhancement may also be achieved by altering habitat attributes – see habitat restoration.

Escapement: The number of mature salmon that pass through (or escape) fisheries and return to fresh water to spawn.

Fallowing: The process of leaving an aquaculture site unused for a period of time in order to facilitate seabed recovery and rehabilitation.

Finite Volume Coastal Ocean Model: A circulation model producing 3D time-varying fields of currents, temperature and salinity by solving the primitive equations with the finite volume numerical technique. Can be used in combination with a sea lice model using the 3D fields to transport lice as they develop through the egg to copepodid life stages.

Fish farming: A production system of raising fish in captivity for the duration of their life cycle until they are harvested.

Fish stocks or Fish populations: All fish that are the same species, but may be genetically distinct from other stocks of the same species. For example, Birkenhead River and Harrison River chinook salmon have significant run-timing, ocean distribution and flesh colour differences even though they are same species originating from the same broad watershed.

Fry: Salmon that have emerged from gravel, completed yolk absorption, remained in freshwater streams, and are less than a few months old.

Genetic Diversity: The variation at the level of individual genes, providing a mechanism for populations to adapt to their ever-changing environment. It refers to the differences in genetic make-up between distinct species and to genetic variations within a single species.

Geographic Diversity: Spatial variability observed within a species. This variation may have a genetic basis and/or may reflect habitat and developmental differences expressed by the species.

Habitat: Spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly to carry out their life processes.

Habitat Indicator: A factor that identifies or indicates a certain environmental condition.

Habitat Restoration: The treatment or cleanup of fish habitat that has been altered, disrupted, or degraded for the purpose of increasing its capability to sustain fish production.

Integrated Disease Management (IDM): An alternative disease control strategy focused on the use of biological and other natural control options.

Integrated Multi-trophic Aquaculture (IMTA): A practice in which the by-products (wastes) from one species are recycled to become inputs (fertilizers, food) for another.

Integrated Pest Management (IPM): A strategy that uses an array of complementary methods. An ecological approach with a goal to significantly reduce or eliminate the use of pesticides.

GLOSSARY OF TERMS

Integrated Land and Resource Registry: Provides a single source of reliable information on over 260 different legal interests on Crown land (tenures, regulated uses, land and resource use restrictions and reservations) from 19 partner ministries and agencies that is visually represented on a map and is available to the public using a standard Web browser.

Integrated Resource Management (IRM): A way of using and managing the environmental and natural resources to achieve sustainable development. Using an IRM approach means that environmental, social and economic issues are considered, while finding ways for all uses to exist together with less conflict.

ISO 65: General requirements for bodies operating product certification systems.

Juveniles: Salmon in their first year(s) of life, traditionally in freshwater streams, rivers or lakes.

Lice Abundance: The total number of parasites (lice) in a sample of fish divided by the total number of fish in the sample, whether or not individual fish have lice.

Lice Intensity: The total number of lice collected divided by the number of fish with an infestation (i.e. the number of lice on those fish that have lice).

Lice Prevalence: The number of cases of a disease or parasite found, divided by the number of subjects examined (i.e. the number of fish with lice divided by the number of fish examined).

Living Rivers Trust: Funded by the Province to provide river and watershed research, establish the sustainable use of water and help undo past damage; examples of activities include: watershed protection and restoration, increasing public awareness of the conservation and sustainable use of water, management and restoration of river flows in systems susceptible to periodic droughts and implementation of recovery plans to restore priority fish populations such as white sturgeon in the Fraser and Columbia Rivers and steelhead in the Georgia Basin.

Morbidity: The prevalence and severity of impacts of disease.

Mortalities: Farmed fish that have died prior to harvest.

Pacific Climate Impact Consortium: Organization dedicated to stimulating collaboration to produce practical climate information for education, policy, and decision-making in the Pacific Northwest.

Pathogen: A virus, bacterium, parasitic protozoan, or other micro-organism that causes infectious disease by invading the body of an organism (e.g. animal, plant, etc.) known as the host. It should be noted that infection is not synonymous with disease because infection does not always lead to injury of the host.

Population: A group of individuals of one species occupying a defined area and sharing a common gene pool. For wild salmon, a localized spawning group of fish that is largely isolated from other such groups.

Precautionary Approach: As defined in the Wild Salmon Policy, the precautionary approach refers to advice provided in situations of high scientific uncertainty. It is intended to promote actions that would result in a low probability of harm that is serious or difficult to reverse.

Productive Capacity: The maximum natural capability of habitat to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms on which fish depend

Riparian Function: Includes vegetation, shade, stream temperature, microclimate, stream bank stability, sediment filtration and flood plane processes.

Run: Genetically similar group of fish having a shared source and destination place or time. In the wild, the group of fish that return to the same geographic area (natal watershed), or that return at the same time period.

Salmonid: A category of fish that includes salmon, steelhead and trout.

Smolt: A juvenile salmon that has completed rearing in freshwater and migrates into the marine environment. Smolts vary in size and age depending on the species of salmon.

Species: The fundamental category of taxonomic classification consisting of organisms grouped by virtue of their common attributes and capable of interbreeding.

Stewardship: Acting responsibly to conserve fish and their habitat for present and future generations.

Stock Assessment: The use of various statistical and mathematical calculations to make quantitative predictions about the reactions of fish populations to alternative management choices.

Sustainable Development: Improving the quality of life within the ecological carrying capacity of supporting systems.

Therapeutants: Medicines used to treat and control diseases, such as antibiotics or pesticides.

Watershed: The region draining into a river, river system, or other body of water.

Wild salmon: Salmon are considered “wild” if they have spent their entire life cycle in the wild and originate from parents that were also produced by natural spawning and lived continuously in the wild.

Year class: The brood year (year the fish was born) or the salt-water entry year that defines a cohort of fish.

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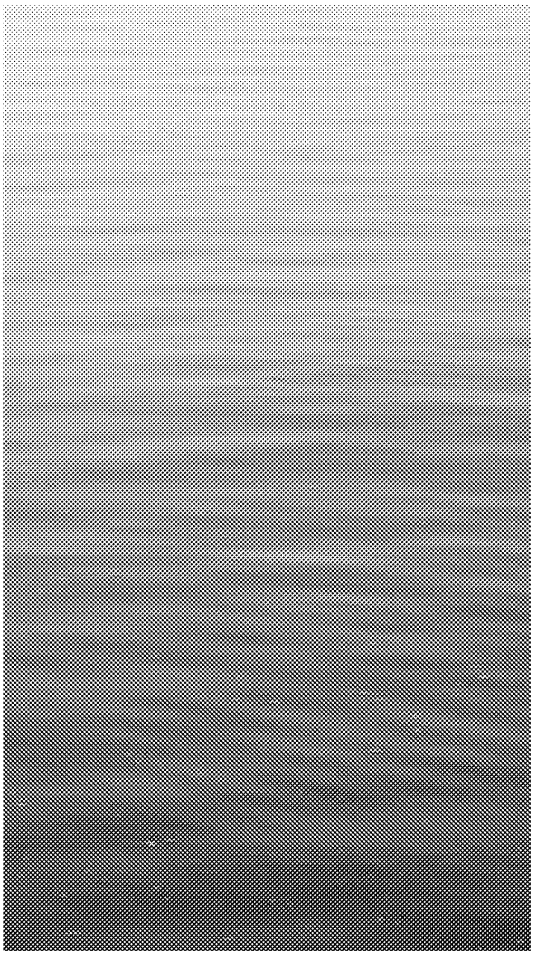

APPENDIX 1
CONSULTATIONS, PRESENTATIONS AND MEETINGS/WORKSHOPS

GENERAL CONSULTATIONS

Aboriginal Aquaculture Association - Richard Harry, Christine Hunt, Morris Harold Sewid, Marguerite Parker

Ad Hoc Gravel Committee - Marvin Rosenau, Otto Langer

AgriMarine Industries - Richard Buchanan

Alby Systems Ltd. - Mike Berry

AquaMetrix Research/Pacific SEA-Lab - Steve Cross

AquaNet Science Committee - Scott McKinley

AquaPort.ca /CO3 Consulting- Tim DeJager

Association of Salmon Fisheries Board (Scotland) - Andrew Wallace

Babine River Foundation - Richard Overstall, Thomas R. Buri

Bellona Foundation (Norway) - Marius Dalen

BC Aquaculture Research and Development Committee - Ruth Salmon, Tim DeJager

BC Auditor General - Wayne Strelioff

BC Centre for Aquatic Health Sciences - Linda Sams, Sonja Saksida, Jim Brackett, Grace Karreman, Kevin Butterworth

BC Coastal Mayors Network - various representatives

BC Innovation Council - Sam Nakai

BC NDP Leader - Carol James

BC Salmon Farmers Association – Board of Directors, Mary Ellen Walling, Technical Committee

BC Seafood Alliance - Christina Burridge

Campbell River Environmental Committee - Stan Goodrich, Thor Peterson

Canadian Aquaculture Industry Alliance - David Rideout

Canadian Climate Impacts and Adaptation Research Network - various representatives

Canadian Parks & Wilderness - various representatives

Coastal Alliance for Aquaculture Reform - various representatives

Communicate Public Affairs - Marc Gage

Council for Gitxsan Watershed Authority - Christine Scotnicki

Council for Tourism Associations of BC - Mary Mahon-Jones, Petrus Ruykes and Board of Directors

Creative Salmon Co. Ltd. - Spencer Evans, Moses Martin, Barb Cannon

David Suzuki Foundation - Jay Ritchlin, Bill Wareham, Jeffery Young

District of Port Edward, Chief Administrative Officer - Ron Bedard

DR Systems Ltd. - Don Reimer

Englewood Processing Plant - Don Millerd

First Nations Fisheries Council – Grand Chief Doug Kelly and other representatives

Fisheries and Oceans Canada:

- Minister Loyola Hearn and Herb Davis, Policy Advisor
- Aquaculture Management - Mark Burgham, Trevor Swerdfager, Andrew Thomson
- Area Director's Office - Mel Kotyk
- Ecosystem Science - Sylvain Paradis
- Oceans, Habitat and Enhancement Branch - Cam West
- Habitat Protection and Sustainable Development - Randy Lake
- Pacific Fisheries Reform - Ron Kadowaki
- Pacific Region Regional Director General - Paul Sprout
- Pacific Science Branch - Laura Richards
- Salmon and Freshwater Ecosystem Division - Brian Riddell
- Salmon Interactions - Richard Beamish
- Molecular Genetics - Ruth Withler
- Wild Salmon Policy - Mark Saunders, Blair Holtby, Jim Irvine

Framework for Dialogue - Dan Johnston, Patrick Armstrong and other MHC and CAAR representatives

Fraser Basin Council - David Marshall, Jessica Bratty, Alison MacNaughton

Friends of Clayoquot Sound - Don Staniford

Friends of Wild Salmon - Gerald Amos, Andrew Williams, Pat Moss

Future SEA Technologies Inc. - Andy Clark

Ganhada Management Group - Allan Okabe

Georgia Strait Alliance - Suzanne Connell

Gitxaal'a First Nation - Chief Clifford White, Verne Jackson and other representatives

Gitxaal'a Treaty Society - various representatives

Gitxsan Watershed Authority Coordinator - Chris Barnes

Golder Associates - Mark Johannes

Government of Canada Trade Commissioner Service - Mary Jane Ginsberg

Grieg Seafood (Norway) - Per Grieg jr.

Grieg Seafood Ltd. - Peter Gibson, Tim Davies, Mia Parker, Barry Milligan

GSGislason & Associates Ltd. - Gordon Gislason

Haisla First Nation - Gerald Amos

Hazelton Municipal Representatives - Doug Donaldson, Dave Ryan, Alice Maitland

Headwaters Initiative - Bruce Hill

Independent - David Blackbourn

Integrated Land Management Bureau - Charlie Short

Integrated Salmon Dialogue Forum - Glenn Sigurdson, Barry Stuart

APPENDIX 1 - CONSULTATIONS, PRESENTATIONS AND MEETINGS/WORKSHOPS

Kitasoo/Xai'Xais First Nation Fisheries & Tourism - Larry Greba

Kitimat Stikine Regional District - Jack Talstra, Bob Cooper

Kitkatla First Nations Outreach Coordinator - Conrad Lewis

Kitlope Management Group - various representatives

KNT First Nations - Dallas Smith, Merv Child

Kristiansund (Norway) - Mayor and Deputy Mayor and Committee for Fisheries

Living Oceans Society - Jennifer Lash, Catherine Stewart

Living Rivers Georgia Basin - Alan Lill

Living Rivers Trust - John Woodward

Mainstream Canada - Fernando Villarroel, Alistair Haughton, Laurie Jensen, Nick DeCarlo, Dusan Munjin

Marine Harvest Canada - Clare Backman, Linda Sams, Keng Pee Ang, Rusty Smith, Diane Morrison

Marine Harvest (Norway) – Gordon Ritchie and other representatives

Marine Stewardship Council - Chris Ninnes, Albert Tacon

Middle Bay Sustainable Aquaculture Initiative - Rob Walker

Ministry of Aboriginal Relations and Reconciliation - Terry Simonson

Ministry of Agriculture and Lands:

* Ministers Stan Hagen and Pat Bell; Deputy Ministers Larry Pedersen and Rory McAlpine
* Aquaculture Development Branch - Harvey Sasaki, Al Castledine, Gavin Last, Bill Harrower, Fiona Cubitt, Myron Roth
* Fish Health - Joanne Constantine, Mark Sheppard, Andrea Osborn
* Licensing & Compliance - Jaclynn Hunter
* Minister Barry Penner; Deputy Ministers Joan Hesketh, Chris Trumpy
* Biodiversity Branch - Ted Down
* Environmental Quality Section - Randy Alexander, Eric McGreer
* Environmental Stewardship - Al Martin and Kristy Ciruna
* Ocean and Marine Fisheries Division - Bud Graham, Jamie Alley, Bob Williams

Ministry of Children and Family Development - Minister Stan Hagen

Ministry of Energy, Mines and Petroleum Resources – Vic Levson, Michelle Schwabe, Colleen Colville

Ministry of Environment

Ministry of Finance - Minister Carole Taylor

Musgamagw Tsawataineuk Tribal Council - Bob Chamberlin, Bill Cranmer, Eric Joseph, Brian Wadhams, Herb Chamberlin, Roy Cranmer, Robert Mountain

Namgis First Nation - Chief Bill Cranmer and other representatives

Nanwakolas Council - Dallas Smith, Chief Harold Sewid, Merv Child and other representatives

National Marine Fisheries Service (USA) - Kevin Amos (National Fish Health), Kate Naughten (Aquaculture)

Nature Conservancy of Canada - Jan Garnett, Kristy Ciruna, Sara Howard, Katharine Ratcliffe, Thomas Swann

New Direction Resource Management Ltd. - W. W. (Bill) Bourgeois

Nisga'a Lisims Government Fisheries & Wildlife - various representatives

North Coast Steelhead Alliance/Poplar Park Lodge - Kathy Larson

Northern Rivers Initiatives - various representatives

Northwest Institute for Bioregional Research - Pat Moss

Norwegian Seafood Federation - various representatives

Nuu-chah-nulth Central Region Fisheries - Mike Jacobs, Katie Beach

Odd Grydeland Consulting - Odd Grydeland

PACE Group – various representatives

Pacific Fisheries Resource Conservation Council - Paul LeBlond, Gordon Ennis and Board of Directors

Pacific Marine Veterinary Services - Grace Karreman

Pacific Organic Seafoods Ltd/Taplow Feeds - Brad Hicks

Pacific Salmon Foundation - Paul Kariya, Diane Ramage, Alan Kenney

Pan Fish Canada - Keith Bullough, Mark Ayranto, Tim O'Hara, Alex Adrian

Pembina Institute - Karen Campbell, Jaisel Vadgama

Port Edward – Mayor Dave MacDonald

PRAqua Supplies Ltd. - Wayne Gorrie

Premier of British Columbia - Gordon Campbell

Prince Rupert – Mayor Herb Pond, Gord Howie

Prince Rupert & Port Edward Economic Development Corporation - Jim Rushton

Prince Rupert Environmental Society - Luanne Roth

Quatsino First Nation/Kwakiutl District Council - Tom Nelson

Raincoast Research Society - Alexandra Morton

Salmon Chile - Rodrigo Infante Varas

Scottish Executive Environment & Rural Affairs - Gordon Brown, Phil Gilmour, Paul Haddon, Stewart Baxter, Judith White

Scottish Quality Salmon - John Webster

Sea Springs Salmon Farm Ltd. - David Groves

Simon Fraser University - Continuing Studies in Science - Patricia Gallaugher

Skeena Economic Group - various representatives

Smithers Chamber of Commerce - Steve Hidber, Heidi Westfall

Special Committee on Sustainable Aquaculture - Robin Austin, Ron Cantelon

Sport Fishing Advisory Board – various representatives

Stolt Sea Farms - Clare Backman

T. Buck Suzuki Society - David Lane, Des Nobles

Target Marine Products Ltd. - Bernie Bennett, Justin Henry

Telkwa – Mayor Sharon Hartwell

Terrace & District Guides Association - Noel Gyger

Tides Canada, Northern River Advisor - Ivan Thompson

Torridon Scotland Area Management Association (Scotland) - various representatives

University of Rhode Island (USA) - Barry Costa-Pierce

University of Victoria, Faculty of Law & School of Environmental Studies - Oliver Brandes

Vancouver Island University:

- Institute for Coastal Resource Management - Grant Murray
- Centre for Coastal Health - Craig Stephen
- Centre for Shellfish Research - Don Tillapaugh

Veterinary Science Opportunities (Norway) - Paul Midtlyng

Watershed Watch Salmon Society - Craig Orr, Stan Proboszcz

Western Economic Diversification - Byron Mah

Wet'suwet'en Fisheries - Walter Joseph, Andrew George Jr.

Wild Salmon Center – Guido Rahr

Wilderness Tourism Association - Brian Gunn, Dean Wyatt, Craig Murray, Jon Caton

World Fisheries Trust - Brian Harvey, Penny Poole

World Wildlife Fund Canada - Chris Elliott, James Casey

World Wildlife Fund International - Jason Clay, Katherine Bostick, Aaron McNevin, Jose Villalon

PRESENTATIONS MADE TO THE FORUM

Aboriginal Aquaculture Association - Richard Harry, Christine Hunt, Chief Harold Sewid, Marguerite Parker and Steve Cross

An Overview of the BC Seafood Sector - Strengths, Weaknesses, Opportunities and Threats - Gordon Gislason, GSGislason and Associates Ltd

Aquaculture Certification – Mary Ellen Walling, BC Salmon Farmers Association

Aquaculture Production and Pre-Site Research - Bill Harrower, Ministry of Agriculture and Lands

AquaNet - Scott McKinley, University of British Columbia

BC Aquaculture Research and Development Committee - Ruth Salmon and Tim DeJager

BC Innovation Council - Sam Nakai

BC Salmon Farmers Association - Mary Ellen Walling

Broughton Archipelago: A State of Knowledge Report - Isobel Pearsall, Pearsall Ecological Consulting

Canadian Environmental Act Assessment Screenings - Andrew Thomson and Randy Lake, Fisheries and Oceans Canada

Closed Containment Panel Presentation - Linda Sams and Rusty Smith, Marine Harvest Canada; Andy Clark, FutureSEA Technologies; Richard Buchanan, AgriMarine Industries, Wayne Gorrie, PR Aqua; Bernie Bennett, Target Marine Products Ltd.

Coastal Alliance for Aquaculture Reform: Sea Lice Research and Science, Solutions, Economics Research, First Nations History - Lynn Hunter, Jennifer Lash, Alexandra Morton, Suzanne Connell, Jay Ritchlin and Chief Bill Cranmer

Coordinated Area Management Plan - Clare Backman, Marine Harvest Canada and Laurie Jensen, Mainstream Canada Ltd.

David Suzuki Foundation Marine Conservation Program - Bill Wareham, Jay Ritchlin and Jeffery Young

DFO Salmon Enhancement Program - Cam West, Fisheries and Oceans Canada

Fallowing for Sea Lice Control - Useful or Not? - Joanne Constantine, Ministry of Agriculture and Lands

Farm Production and Health Regulations - Mark Sheppard and Bill Harrower, Ministry of Agriculture and Lands

Finfish Aquaculture Licensing, Regulations and Compliance - Jaclynn Hunter and Bill Harrower, Ministry of Agriculture and Lands

Finfish Aquaculture Waste Control Regulation - Randy Alexander and Eric McGreer, Ministry of Environment

Fish Health Management Plans - Joanne Constantine, Ministry of Agriculture and Lands

Fish Health Management Plans & Fish Health Research - Sonja Saksida, BC Centre for Aquatic Health Sciences and Grace Karreman, Pacific Marine Veterinary Services

Genetics and Salmon Enhancement - Ruth Withler, Fisheries and Oceans Canada

Getting the Message Out: Ensuring that Salmon Farming and Wild Pacific Salmon Coexist Successfully, and an Overview of Ocean Conditions Affecting Salmon Returns - Richard Beamish, Fisheries and Oceans Canada

Gravel Extraction - Marvin Rosenau, BCIT and Otto Langer, Ad Hoc Gravel Committee

Gravel Extraction - A Regulatory Perspective - Mel Kotyk, Fisheries and Oceans Canada

Joint Meeting with Nanwakolas Council Representatives - Dallas Smith, John Cathro and Chief Harold Sewid

Kitasoo Fisheries Program - Larry Greba

Marine Harvest/CAAR Framework for Dialogue - Clare Backman, Marine Harvest Canada and Catherine Stewart, Coastal Alliance for Aquaculture Reform

Marine Stewardship Council Certification - Christina Burridge, BC Seafood Alliance

Pacific Fisheries Reform - Ron Kadowaki, Fisheries and Oceans Canada

Provincial Ocean & Marine Fisheries Division - Organization & Activities - Bud Graham, Ministry of Environment

Quinsam Coal - Stan Goodrich and Thor Peterson, Campbell River Environmental Committee

Risk Analysis Model Development for Application to Aquaculture Overview and Background on Land Use Planning and Aquatics Modeling - Don Reimer, DR Systems and Linda Sams, Centre for Aquatic Health Sciences

Salmon Forever: An Assessment of the Provincial Role in Sustaining Wild Salmon - Wayne Strelioff, BC Auditor General

Sport Fishing Advisory Board Planning and Comment on Forum Interim Report - Rupert Gale, Sport Fishing Advisory Board

State of Wild Salmon in the Broughton Archipelago and Region - Mark Johannes, Golder Associates Ltd.

Stream Assessments in Siting Salmon Farms - Clare Backman and Sharon DeDominicis, Marine Harvest Canada

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Sustainable Aqua-Food Innovation Partnership - Linda Sams, BC Centre for Aquatic Health Sciences; Grant Murray and Don Tillapaugh, Malaspina University-College; Tim DeJager, DeJager AquaLogic and Steve Cross, AquaMetrix Research

Wild Pacific Salmon, Salmon Farms and Sea Lice - Brian Riddell, Fisheries and Oceans Canada

Wild Salmon Policy/Conservation Units and Information System Presentation: Next Steps in the Implementation of Canada's Policy for Conservation of Wild Pacific Salmon. The Identification of Conservation Units - Mark Saunders, Blair Holtby and Jim Irvine, Fisheries and Oceans Canada

Wilderness Tourism Association Perspective on Salmon Farming in the Broughton - Brian Gunn, Dean Wyatt, Craig Murray and John Caton

WWF Canada/Coast Tsimshian Resources Ltd. Partnership Water Conservation - Bill Bourgeois and James Casey

CONFERENCES/WORKSHOPS ATTENDED

7th International Sea Lice Conference, Chile

Adapting to Climate Change: Business Planning, Risk Management, Emergency Preparedness, Ottawa

Alaska State of the Salmon Conference 2005

Aquaculture and Innovation: Progress and Challenges, Nanaimo

Aquaculture Canada 2007, Edmonton

Aquaculture Canada 2008, Saint John

Aquaculture Pacific Exchange, Campbell River

AquaNet V - The Role of Aquaculture in Meeting Global Seafood Demand, Victoria

AquaNor 2005, Norway

Aquaport.ca Workshop, Nanaimo

AquaSur 2008, Chile

AquaVision 2006, Norway

BC Salmon Farmers Association Annual General Meetings, Campbell River

BC Seafood Alliance Seafood Summit, Vancouver

BC Water Governance Workshop, Nanaimo

Canadian Institute for Justice Administration Sustainability Conference, Vancouver

Canadian Oceans Lecture, Vancouver

Canadian Science Advisory Secretariat Closed Containment Review Meeting, Sidney

Climate and Fisheries, Victoria

Climate Change in our Community, Nanaimo

Community Engagement and the Governance of Coast Social-Ecological Systems, Vancouver

Council of Tourism Associations of BC, Vancouver

Earth Oceans Forum, Victoria

Farmed & Wild Salmon Working Together, Norway

Fisheries and Oceans Canada Aquaculture Certification Workshop, Ottawa

Fisheries and Oceans Canada Values Workshop, Vancouver

Fisheries Summit, Terrace

Fraser Assembly, Vancouver

Fraser Basin Council – Water Governance Workshop, Nanaimo

Friends of Wild Salmon Summit, Terrace

Georgia Strait Ecosystem Symposium, Vancouver

Institute for Coastal Research Symposium and Workshop, Nanaimo

International Joint Commission on Pacific Salmon Restoration, Seattle, WA

National Aquatic Animal Health Program - Ottawa

Pacific Fisheries Resource Conservation Council, Duncan

Pacific Salmon Treaty Workshop, Stanford, CA

Role of Aquaculture Conference, Seattle, WA

Skagit Environmental Endowment Commission, Blaine, WA

Speaking for the Salmon - Encouraging Innovative Solutions for Sustainable Salmon Aquaculture, Vancouver

Speaking for the Salmon - Fraser Sockeye Salmon: Moving From Talk to Action, Vancouver

Speaking for the Salmon - Workshop on Groundwater and Salmon, Vancouver

Speaking for the Salmon - Getting the Missing Fish Story Straight: Part II – A Ten Year Retrospective on Fraser Sockeye Salmon, Vancouver

Speaking of Science - Ecological Aquaculture - Vancouver

Special Committee for Sustainable Aquaculture Public Meetings, Nanaimo

West Coast Vancouver Island Aquatic Management Board, Port Alberni

Wild Salmon Policy Consultation Meeting, Vancouver

World Aquaculture Conference 2006, Florence, Italy

World Aquaculture Conference 2007, San Antonio, TX

WWF Conference 2005, Vancouver

WWF Salmon Dialogues, Washington, DC, Italy, Vancouver, Chile

SPEAKING OPPORTUNITIES

Adapting to Climate Change: Business Planning, Risk Management, Emergency Preparedness, Ottawa

Aquaculture and Innovation: Progress and Challenges, Nanaimo

Aquaculture Canada 2008 - Saint John

Canadian Institute for Justice Administration Sustainability Conference, Vancouver

Canadian Oceans Lecture, Vancouver

Climate Change in our Community, Nanaimo

Community Engagement & the Governance of Coast Social-Ecological Systems - Vancouver

Council of Tourism Associations of BC, Vancouver

Ministry of Agriculture and Lands, Campbell River

Pacific Salmon Treaty Workshop, Stanford, CA

Skagit Environmental Endowment Commission, Blaine, WA

State of the Salmon, Anchorage, Alaska

Vancouver Island University – Centre for Coastal Health, Nanaimo

West Coast Vancouver Island Aquatic Management Board, Port Alberni

APPENDIX 2
ENGAGEMENT WITH RESEARCHERS

SCIENCE ADVISORY COMMITTEE MEMBERS 2005 TO 2008

Dr. Jim Brackett

Dr. Larry Dill

Dr. Anthony (Tony) Farrell

Dr. Don Furnell

Dr. Al Lewis

Dr. Don McQueen

Dr. Bill Pennell

Dr. John Reynolds

Dr. Brian Riddell

Dr. Eric (Rick) Taylor

OTHER RESEARCHERS

Ackerman, Paige - University of British Columbia

Afonso, Luis - National Research Council of Canada

Ang, Keng Pee - Marine Harvest Canada

Beach, Katie - Nuu-chah-nulth First Nation

Beamish, Richard - Fisheries and Oceans Canada

Berry, Mike - Alby Systems Ltd.

Black, Edward - Fisheries and Oceans Canada

Boxaspen, Karin - Institute of Marine Research, Bergen, Norway

Boyce, Brad - Marine Harvest Canada

Brackett, Jim - BC Centre for Aquatic Health Sciences

Brauner, Colin - University of British Columbia

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Brown, Robin - Fisheries and Oceans Canada

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Cannon, Barb - Creative Salmon Co. Ltd.

Carr-Harris, Charmaine - Oona River Resource Association

Chamberlain, Jon - Fisheries and Oceans Canada

Connors, Brendan - Simon Fraser University

Constantine, Joanne - Ministry of Agriculture and Lands

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Hargreaves, Brent - Fisheries and Oceans Canada

Harvey, Brian - Fugu Fisheries

Hinch, Scott – University of British Columbia

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Ikonomou, Michael – Fisheries and Oceans Canada

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Morton, Alexandra - Raincoast Research Society

Mullins, Julia - Pan Fish Canada

Murray, Alexander (Sandy) – FRS Marine Laboratory, Scotland

Nendick, Laura - University of British Columbia

Neville, Chrys - Fisheries and Oceans Canada

Newton, Craig - Vizon SciTec Inc.

Novales-Flamarique, Inigo - Simon Fraser University

Orr, Craig - Watershed Watch Salmon Society

Osborn, Andrea - Ministry of Agriculture and Lands

Osborne, Josie - Redfish Bluefish Consulting and WCVI Aquatic Management Board

Palermo, Vic - Fisheries and Oceans Canada

Parken, Chuck - Fisheries and Oceans Canada

APPENDIX 2
ENGAGEMENT WITH RESEARCHERS

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Proboszcz, Stan - Watershed Watch Salmon Society

Proctor, Bart - Oona River Resource Association

Randall, David - University of British Columbia

Reynolds, John - Simon Fraser University

Revie, Crawford - University of Strathclyde, Glasgow and University of Prince Edward Island

Riddell, Brian - Fisheries and Oceans Canada

Ross, Neil - National Research Council of Canada

Routledge, Rick - Simon Fraser University

Sackville, Michael - University of British Columbia

Saksida, Sonja - BC Centre for Aquatic Health Sciences

Sheppard, Mark - Ministry of Agriculture and Lands

Stephen, Craig - Vancouver Island University

Stockwell, Margot - Fisheries and Oceans Canada

Stucchi, Dario - Fisheries and Oceans Canada

Sweeting, Ruston - Fisheries and Oceans Canada

Tang, Stephen – University of British Columbia

Taylor, Rick - University of British Columbia

Trudel, Marc - Fisheries and Oceans Canada

Van Will, Pieter - Fisheries and Oceans Canada

Volpe, John - University of Victoria

Waddy, Susan - Fisheries and Oceans Canada

Wade, Joy - Fisheries and Oceans Canada

Webster, Sandra - Simon Fraser University

Welch, David - Pacific Ocean Shelf Tracking Project (POST)

Wiebe, Gabe - University of British Columbia

APPENDIX 3 - SUMMARY OF FORUM FUNDED KEY RESEARCH RESULTS

3A – EVALUATION OF THE BROUGHTON RESEARCH PROGRAM BY THE SCIENCE ADVISORY COMMITTEE TO THE BC PACIFIC SALMON FORUM

The Science Advisory Committee (SAC) was established by the BC Pacific Salmon Forum three years ago to advise on the overall research program for the Forum, provide specific advice on individual research projects and prepare an overall assessment of the research program. This document presents this overall assessment.

The main focus of the research funded by the Forum was on the interactions between sea lice infestation of wild juvenile salmon in the Broughton Archipelago (hereafter referred to as 'the Broughton') and the role that salmon farming played in contributing to this infestation. Following the collapse of the pink salmon population in the Broughton in 2002, there has been a significant amount of research into this interaction. Results from some published scientific studies up to 2007 were contradictory and there remained significant gaps in knowledge. The Forum, with our advice decided to mount a two-year research program in the Broughton to provide new information and see if it could provide a firmer basis for the Forum to provide advice to the provincial government on future management of fish farms and the interactions between salmon farms, sea lice, and wild juvenile salmon.

Scientific debates about the potential negative impacts of open net pen salmon farming on wild salmon due to sea lice infestations in the Broughton, and elsewhere, continue to this day. Although the SAC and researchers have drawn on extensive published evidence concerning sea lice infections on wild populations from Europe where there is a longer history of salmon farming, there remain a number of significant information gaps in the BC context, which have hampered formulation of clear management policies.

The BC Pacific Salmon Forum encouraged a number of researchers to collaborate and to apply rigorous scientific methods to focus primarily on sea lice interactions between farmed and wild fish in the Broughton, and to compare results, where possible, to studies in the Bella Bella area on the Central Coast, an area with no fish farms. The Forum also funded a limited amount of monitoring of sea lice in the Clayoquot, Klemtu and Skeena areas of BC.

The need for clear answers to these issues has been heightened in the fall of 2008 by the decline of pink salmon returns to streams in the Broughton to an all-time low since records began in 1954 (Van Will & Riddell – BCPSF Project C.1-2). While many areas along the BC coastline that lack fish farms have also seen very low returns this year, possibly related to unfavourable ocean conditions, there is an urgent need

to clarify what, if anything, can be done to reduce the impact of farming activities to avoid any further mortality to the low numbers of juvenile salmon expected in the spring of 2009.

In this report we have concentrated on the species of sea lice known as *Lepeophtheirus salmonis* as this species is generally associated with salmon farms and is the prevalent species of sea lice found on wild salmon in the Broughton.

We note that there remain significant uncertainties in evaluating the preliminary results of the science which is presented in Appendix 3B and 3C Summary of 2007 and 2008 Interim Research Findings. The extremely complex Broughton ecosystem encompasses many interacting environmental factors that make reaching clear scientific conclusions all the more difficult. Accordingly, we have taken the precautionary approach in environmental management in reaching our conclusions and making our recommendations to the Forum.

The BC Pacific Salmon Forum established three objectives for the Broughton Research Program. These were:

1. TO DETERMINE WHETHER SALMON FARMS IN THE BROUGHTON IMPACT SEA LICE LOADS ON WILD SALMON AND IF SO HOW?

2. TO DETERMINE WHETHER THE SURVIVAL OF INDIVIDUAL WILD FISH IS COMPROMISED DUE TO INCREASED SEA LICE LOADS

3. TO DETERMINE IF ANY REDUCED SURVIVAL OF INDIVIDUAL SALMON HAS CONSEQUENCES FOR SALMON POPULATIONS, AND IF SO, WHETHER THERE ARE FARM MANAGEMENT TECHNIQUES THAT CAN BE PUT IN PLACE TO MITIGATE ANY RISK TO WILD SALMON?

All references to specific BCPSF Projects are found in the 2008 Research Summary unless otherwise noted.

As a clarification for the Forum, the Broughton ecosystem is considered to encompass the area within the boundaries of Knight Inlet to the South and Wells Passage to the North. Three aquaculture companies have facilities in this region with Mainstream Canada Ltd. and Marine Harvest Canada comprising all but one of the seapen operations within these boundaries. Although Grieg Seafood BC Ltd. operates one facility at Bennett Point they are not yet represented in the coordinated area management plan (CAMP) proposed by Mainstream and Marine Harvest. We recommend that they should be integrated into the CAMP.

1. DO SALMON FARMS IN THE BROUGHTON CONTRIBUTE TO SEA LICE LOADS ON WILD SALMON?

There is very strong indirect evidence that salmon farms in the Broughton, and elsewhere on the BC coast, contribute sea lice to wild juvenile pink and chum salmon. The magnitude of this effect depends on farm management measures that have been increasingly adapted to greatly reduce the number of sea lice present on farms over the past four years in the Broughton. Evidence of increased sea lice around salmon farms was also apparent from the greater number of planktonic sea lice stages found near to and distant from farms.

Sea lice exist naturally in the Pacific Ocean and have done so long before fish farms were installed on the

BC coast. Farmed salmon, when stocked in sea pens, are initially free of sea lice but become infected from outside sources over time. To date we are aware of no study that has directly assigned a sea louse on a wild fish as having an origin from a salmon farm. There is, however, a strong association between sea lice levels on farms and sea lice levels on wild fish. The effect of fish farms has been inferred by comparing *L. salmonis* levels on wild juvenile pink and chum salmon near farms with levels on those that have been captured further away from farms as well as a greater concentration of larval sea lice in the plankton near farms. It is also useful to compare *L. salmonis* levels on juvenile pink and chum in regions where there are no salmon farms. Together these lines of inquiry have produced a very strong weight of evidence that salmon farms can contribute sea lice to juvenile pink and chum salmon.

When juvenile salmon were collected from areas that were located >1 km from farms, the sea lice prevalence was generally found to be lower compared to areas within 1 km of farm sites. In the Bella Bella region of the Central Coast of BC, where there are no salmon farms, the prevalence of all species of sea lice (% of individuals carrying at least one sea louse) averaged 3.5% during 2007 and 2008 (Price and Reynolds – BCPSF Project C.3). Results for the Bella Bella region were virtually identical to those found in the Klemtu region to the north, where reference sites were >1 km away from active fish farms and where the average prevalence of *L. salmonis* on juvenile wild pink and chum salmon was six times higher close to farms (Price and Reynolds – BCPSF Project C.3). The results for the Klemtu region were echoed by another study by Saksida and Greba (BCPSF Project D.1), where sea lice prevalence was three to five times higher near farms compared with sites further away. Similarly, near Campbell River the prevalence of sea lice on juvenile salmon was higher near to farms than further away (Price and Reynolds – BCPSF Project C.3). Louse prevalence in the Broughton has also been shown to be higher near farms (e.g. Morton *et al*, 2004, Krkosek *et al*. 2006). The strength of this association varied between pink and chum salmon, sea lice development stage, and between years. The pattern of association among the variables examined was, however, fairly consistent among years (Krkosek *et al* 2007, Saksida *et al* – BCPSF Project D.3).

The sea louse prevalence levels from Bella Bella and from Klemtu, away from farms, are considerably lower than in the Broughton, where prevalence has been recorded as high as 70% in 2004, but has decreased substantially since then. The results from Forum-funded research in 2007 indicate that during the pink salmon out migration period March to May, the average prevalence of *L. salmonis* (the species of louse amplified by fish farms) was 13.2% on pink and 19.5% on chum salmon (Jones and Hargreaves - BCPSF Project A.7). During the same period in 2008, in the farm free region of Bella Bella, the average prevalence of *L. salmonis* was even lower at 1.5% for pink and 2.6% for chum, which are equal to or less than background levels from other studies. Variability in sea louse prevalence in the Broughton has also been reported by others (Morton *et al*, 2004; Jones and Nemec 2004; Morton, *et al*. 2005, Jones and Hargreaves 2007).

Sea lice levels are amplified by salmon farms but the

strength and direction of currents, the limited length of time the planktonic stages of sea lice can live without a host, the impacts of temperature and salinity on development and survival of lice, and predation on sea lice by other organisms, all affect how far they are dispersed and the likelihood of locating a host. It is important to note that the majority of sea lice released from a farm almost surely do not find a host, their lifespan being limited to less than a month, and subject to unknown predation pressure. It is also established that sea lice numbers increase during the winter months and that recently some farms have treated farmed fish with SLICE™ at that time, thereby reducing sea lice populations to near zero in the spring (BCPSF Projects A.3, A.7, A.9) which is when pink salmon begin their out migration. Tides, currents and surface winds can move larvae both away from and towards salmon farms. The young stages of sea lice (larvae) that are not attached to a host and drift with the currents (plankton) are able to travel, although it is not clear how far they are dispersed. Within the Broughton, oceanographic modeling has helped to shed light on potential mechanisms of transport of sea lice larvae around and away from farms (Stucchi *et al* – BCPSF Project A.1).

A clear understanding of sea lice abundance in the Broughton hinges on knowledge regarding their distribution in the water column as well as their interaction with salmon. One BCPSF project examined sea lice abundance over a large geographical region by performing surface (top 1 m of water) plankton tows. The plankton tows in 2007 and 2008 found an increase in both naupliar and copepodid stages of sea lice near salmon farms, although abundances were low (ranging from 0-9 per tow where each tow represented 40-60 cubic metres of water filtered) Planktonic stages of sea lice can be found at various distances from salmon farms. Nauplii were collected within 5-8 km of salmon farm sites and copepodids up to 20 km from farms (Mackas and Galbraith – BCPSF Project A.5), although the source of the larvae is unknown. These findings may be useful for generating estimations of sea lice density around farms to indicate zones of potential impact that could be investigated using the Finite Volume Coastal Ocean and particle tracking models. Other studies, however, have shown relatively low background prevalence of sea lice on juvenile salmon as close as 1 km from farms. Because of the variability in environmental factors and the variation in site oceanography and hydrography, we do not know how far from active salmon farms the minimum threshold for sea lice prevalence on juvenile salmon recommended later in this report will occur. Nauplii and copepodids are observed around fish farms that contain fish and the levels of sea lice decrease with distance from farms due to such factors as sea lice dilution, predation, or death due to failure to find hosts. With the data that are currently available, we do not have sufficient information to reach a conclusion on the dispersion rates from farms and the required distances between farms to minimize wild fish infection. We recommend that further work be undertaken in this area.

To examine the vertical distribution of the planktonic larvae, a field study investigated their distribution in a finite volume sea water column over a 10 m depth range (surface to 10 m), both in the presence and absence of juvenile pink salmon. This field study found

that in the absence of available hosts the larvae did not exhibit any particular depth preference at any time of the day or night (Lewis *et al* – BCPSF project A.6). When juvenile salmon, up to approximately 0.5 gram, were added, in the absence of sea lice, they were typically found in the uppermost 4 m of the same 10 m column during the day and in the top 1 m at night. When salmon and sea lice were placed together in the column, both fish and copepodids had a similar distribution pattern (Tang in Lewis *et al* – BCPSF Project A.6). A study in the 2007 research period (Losos – 2007 Project Report 5B) demonstrated that sea lice are attracted to water conditioned with juvenile salmon although another study by the same author demonstrated that sticklebacks ate sea lice and egg strings from sea lice attached to juvenile salmon. From these data it seems reasonable to conclude that sea lice are attracted to juvenile salmon as a potential host and it is possible that sticklebacks (and perhaps juvenile salmon) seek out sea lice as a potential food source.

2. IS THE SURVIVAL OF INDIVIDUAL FISH COMPROMISED DUE TO SEA LICE LOADS?

Studies in the laboratory and in field enclosures provide clear evidence of lethal and sub-lethal effects of sea lice on individual juvenile pink salmon, but the effects are strongly dependent on the size of the fish, the developmental stage of the louse, and the number of sea lice on the fish. There is a consensus amongst laboratory studies that fish 0.5 gram or less are more susceptible to sea lice and this susceptibility decreases as the fish grow.

It is difficult to determine the level of infestation at which sea lice numbers affect individual fish. Laboratory studies provide one source of information because they can control many potentially confounding variables. Laboratory studies, however, are difficult to extrapolate to the wild, where the fish must contend with predators, variable environmental conditions and many other pathogens in addition to sea lice. At present, the level and consequences of interactions amongst other biotic and abiotic factors that may be relevant to the effects of sea lice infections on salmon are unclear (Marty *et al*- BCPSF Project B.6). Conversely, studies on the health of fish that have become infected in the wild are difficult to interpret with respect to cause and effect. Are fish infected by sea lice because they are weak and unhealthy due to some other cause, or do sea lice infections render fish susceptible to other environmental or pathological influences that reduce their survival, or do both situations occur?

Previous research using juvenile pink and chum reared in barrels in the sea indicated significant juvenile mortality from a single copepodid or early chalimus-stage louse (Morton and Routledge 2005). No data on fish weight or length were presented in the Morton and Routledge study, but the experiments began in mid-March when most fish were probably under 1g. Mortality rates, however, can vary depending on experimental conditions. For instance, Jones *et al* (2008) reported 35% of 0.3 g pink salmon died under laboratory conditions after exposure to a much higher intensity of *L.salmonis* - an average of 4.7 sea lice per fish (Jones *et al* 2008). Another laboratory study that evaluated sub-lethal effects reported low mortality (less than 2% among 5,000 fish) with in-

tensities of below three sea lice on pink salmon less than 0.5 g and no mortality with single copepodid and chalimus stage infections (Brauner and Farrell *et al* - BCPSF Project B.1-4). Thus in these laboratory experiments, the number of lice required to kill juvenile salmon is much higher than reported in field studies.

Laboratory studies were used to examine the relationships between sea lice infestation and sub-lethal effects on juvenile pink salmon, which are likely to be manifested before mortality. In the laboratory, wild ocean-caught juvenile pink salmon 0.5 g or smaller exhibited reduced ionic regulation ability when infected with one chalimus^{-3} stage louse (pre-adult) or greater, and an 18% decrease in peak swimming performance. Pink salmon, with a mass greater than 0.5 gram and hosting one louse, suffered no appreciable ionic disturbance or decrease in swimming ability in the laboratory. Further, several researchers have noted that there appears to be a considerable degree of shedding of sea lice as fish exceed 1 g in mass (Brauner and Farrell *et al*.- BCPSF Project B.1-4). Thus, not all copepodid infections are successful in producing egg-bearing female sea lice, and this supports other studies that demonstrate that as fish grow they become more resistant to the effects of sea lice.

In laboratory trials, a level of 7.5 sea lice per gram of fish weight (3-4 sea lice on a 0.5 g fish) was reported to be lethal (Jones and Hargreaves – BCPSF Project A.7). Intensive field monitoring programs in the Broughton in 2007 and 2008 measured levels of sea lice on juvenile pink and chum (Hargreaves and Jones – BCPSF Project A.3) and, using the same threshold level, found no lice levels on pink salmon juveniles that would produce fish mortality (Jones and Hargreaves - BCPSF Project A.7). There are, however, two difficulties with these results. First, we note that wild fish that may have already died as a result of sea lice infestation would not be represented in the catches in the monitoring programs. Second, there is difficulty in extrapolating laboratory data on sub-lethal effects to the field, particularly when the extrapolation is based on a single study with exposure to high sea lice abundance (Jones *et al* 2008). As the season progresses and salmon become larger, however, they become more resistant to the impacts of sea lice (Brauner *et al* - BCPSF Project B.1-5, Jones *et al* 2008).

3. DO IMPACTS OF SEA LICE FROM FARMS ON INDIVIDUAL FISH TRANSLATE INTO IMPACTS AT THE POPULATION LEVEL, AND ARE THERE FARM MANAGEMENT TECHNIQUES THAT CAN MITIGATE RISK TO WILD SALMON?

Laboratory studies indicate that sea lice have an effect on individual juvenile pink salmon but it is difficult to extrapolate these data to a population level. Evidence suggests that salmon farm-based sea lice production and/or environmental factors can affect salmon population sizes. Population level effects can be measured as the numbers of returning adults to coastal waters in relation to the numbers of adults spawning in the previous generation. This is the net result of numerous factors through a species' life cycle and may not be determined solely by changes in juvenile mortality. Management practices have been successful in reducing sea lice on the farms and are likely associated with the reduction in levels of sea lice on nearby wild salmon.

Although there have been significant declines in adult pink salmon returns to the Broughton, it needs to be emphasized that many factors affect adult returns beyond juvenile survival prior to and following salt-water entry. These include environmental conditions in the marine setting, availability of food resources during critical periods, pathogens and predation, as well as impacts of sea lice. Ocean conditions play a large role in determining adult salmon returns and these effects are very difficult to separate from effects on juvenile salmon life stages, unless survival rates can be estimated by life stages. As an example, in recent years, pink salmon populations have decreased all along the BC coastline (Fisheries and Oceans Canada 2007), including in the Broughton. At the same time, sea lice populations in the Broughton have also been decreasing. This illustrates that there are factors in addition to sea lice that affect juvenile pink salmon survival and therefore adult returns and that these factors may have a greater impact on fish populations than sea lice alone. Further, the difficulty in attributing cause and effect between life stages is graphically evident in conflicting opinions expressed to explain the stronger return of Broughton pink salmon in 2004. Did the return reflect the fallowing conducted in spring 2003, as suggested by Krkosek *et al*. (2007), or strong marine survival of all life stages as reported by Beamish *et al*. (2006), or both?

Krkosek *et al*. (2007) showed a significant decline in wild pink salmon populations in the Broughton compared with other regions on BC's Central Coast that lack salmon farms, and thus implicated farm-based sea lice production as a major factor affecting wild pink salmon population productivity. This is consistent with the results of a global analysis from 10 regions (including the Broughton) by Ford and Myers (2008), which included additional impacts not relevant to the Broughton, such as hybridization between farmed and native wild Atlantic salmon. The data and extrapolations in the Krkosek *et al* (2007) study were, however, based on farm management practices used prior to 2006. The number of sea lice on wild juvenile salmon has been decreasing in the Broughton region since 2004.

The effect of SLICE™ treatment on salmon farms in the winters of 2006-2008 on reducing sea lice populations has been modeled (Krkosek *et al*- BCPSF Project A.4). The decline in sea lice levels on juvenile salmon may be due, in part, to changes in management of sea lice on salmon farms. Environmental changes in the Broughton, however, including changes in salinity and temperature, also may be associated with the decline in sea lice prevalence over the years. In May 2004 and 2005, salmon farms applied SLICE™ according to regulatory requirements when the trigger value of three motile sea lice per fish was reached. Since 2006, farms have voluntarily treated in a precautionary manner, prior to the three sea lice trigger, to greatly reduce sea lice levels on farmed salmon prior to juvenile pink and chum out-migration. Early harvest on some farms has also contributed to reductions of sea lice numbers on salmon farms during juvenile out-migration.

Marine Harvest and Mainstream have proposed to implement a coordinated area management plan (CAMP) in 2009 to ensure different migration corridors are free of farmed salmon in alternate years. They intend to harvest fish by March at six sites.

five of which are in the Fyfe Sound/Tribune Channel migration route. All remaining farms in the region will be monitored and must be treated before the three motile sea lice regulatory trigger level is reached. It will be important that this treatment occurs before mid-February in advance of the out migration of juvenile pink salmon.

4. FUTURE MONITORING AND RESEARCH PRIORITIES

Monitoring of sea lice on farmed and wild salmon should continue in March - May of each year in the Broughton, with particular attention in 2009 to assess the effectiveness of the proposed coordinated area management program by the operating companies. Sea lice monitoring should also continue in other farming areas outside the Broughton to understand the relationships between farmed and wild salmon in different systems with respect to the recommended farm treatment thresholds for sea lice prevalence and abundance. These monitoring programs should also include measurements of salmon length and mass and provide information of the relationship between sea lice load and salmon body size.

Sentinel cages should be implemented as a useful monitoring tool for determining dispersion and infectivity of sea lice. This is recommended as a higher priority over further plankton tow monitoring, as it will provide a more direct measure of the impact of changes in sea lice abundance in the near farm environment.

The dynamic ocean model initiated by the Forum's research program will provide a continued valuable platform for investigating water circulation and sea lice distribution patterns at the ecosystem level. Further data on winds, currents, and river discharge flows need to be collected over winter and spring. An excellent start to modeling the flows through the system has been achieved, but further exploration and calibration of the particle tracking within the system is required. In particular, the question of where planktonic sea lice larvae go when they are released from the sea pens needs to be addressed to better evaluate future salmon farm siting.

Fisheries and Oceans Canada should maintain detailed escapement monitoring in the Broughton as well as fry counts from the Glendale system (as developed in collaboration with the BCPSF) to evaluate effects of farm management practices at the population level.

Finally, we support the full implementation of the study underway to evaluate the effects of SLICE™ on water, sediment and non-target organisms.

RECOMMENDATIONS

Based on the research summarized above, our advice to the Forum is as follows:

1. **Based on our review of natural background levels of sea lice outside the Broughton, no more than 3% of juvenile wild pink and chum salmon of 0.5 gram or less should have more than one chalimus^{-3} or later pre-adult stage of *L. salmonis* between March 1- May 31.**
2. **Strict adherence to the coordinated area management plan proposed by the two main companies (Mainstream and Marine Harvest)**

operating in the Broughton for 2009 will be necessary to minimize risks associated with sea lice contributed by salmon farming. For 2009, government must be prepared with enforcement actions to protect juvenile pink salmon in the Broughton if the industry's area management plan is not strictly adhered to. It is our recommendation that Grieg Seafood's farm at Bennett Point must also be included in this strategy.

3. Governments should ensure that the companies receive amendments, if required, to their operational licenses to enable the coordinated management regime in the Broughton to be implemented over five years.
4. If the 3% sea louse threshold on wild fish is exceeded while the Broughton coordinated area management plan is strictly adhered to, and extended to all farms operating in the Broughton, this would likely be due to natural fluctuations in sea louse populations, rather than farm management practices.
5. A scientifically rigorous program of sea lice monitoring on both farmed and wild fish should be conducted over at least the next five years along with continuation of work on the Finite Volume Coastal Ocean Circulation and Particle Tracking Circulation Models. Wild salmon escapement must also be monitored.
6. As a precautionary approach to protecting the environment, there should be no net increase from 2008 levels in farm production in the Broughton. In five years an evaluation of potential increases or decreases in production should be conducted, based on the monitoring results.
7. In the Broughton we recommend that the regulatory regime for treating sea lice should be amended to reduce sea lice populations on farms, to as close to zero as possible and certainly less than the three motile trigger that currently exists, during March to May prior to and during the out-migration period. Where there is appropriate sea lice monitoring in place, the current regulation may be applied in a more flexible manner later in the year, when wild fish are larger and have increased resistance to sea lice.
8. As a precautionary approach to protecting wild salmon, there should be no net increase in current farm production (2-year cycle) in any other operating area of the BC coast. Potential future farm production in terms of lice management would be contingent upon maintaining lice levels at or below background levels and meeting the criteria set out for the Broughton in #7 above. Other existing environmental criteria affecting production would also have to be met.
9. Research to develop improvements to salmon farming to increase its ecological sustainability are strongly encouraged. This includes research on closed containment approaches to production, safeguards to fish health, reductions in escapes, and other measures.

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3B – SUMMARY OF 2008 INTERIM RESEARCH FINDINGS

The 2008 BCPSF research program contributed a great deal of new data to the knowledge base regarding ecological interactions in the Broughton Archipelago and beyond. Some of the key findings from each study are highlighted below. It is important to note, however, that the following information is based on preliminary reports of projects that have not been subject to formal peer review.

Oceanography

Circulation and sea lice dispersion models have been developed for the Broughton Archipelago and used to simulate oceanographic conditions and lice concentrations for the period of March 13 - April 3, 2008 (A.1). Modeled currents, salinities and temperatures were found to agree relatively well with data collected from the field. Lice concentrations shared some qualitative observations that were made during plankton sampling surveys (A.5). Further simulations and evaluations are planned for three-week runs that cover the February, May, and June 2008 sampling periods. These models should prove to be useful tools for investigating wild/farmed salmon interactions with sea lice and examining farm management strategies in the future.

Natal Origins of Juvenile Pink and Chum Salmon

Micro-chemical analyses demonstrated that it is possible to discriminate the natal origins of pink and chum salmon sampled in the Broughton Archipelago. Salmon of known origin were correctly identified approximately 85% of the time. This research could provide a useful analytical tool in the ongoing efforts to better understand salmon migration pathways in the Broughton Archipelago (A.2).

Marine Monitoring of Juvenile Pink and Chum Salmon and Sea Lice

DEFINITIONS

Prevalence is defined as the number of cases of a disease or parasite found, divided by the number of subjects examined. (i.e. the number of fish with lice/ the number of fish examined)

Lice Intensity is defined as the total number of lice collected divided by the number of fish with an infestation. (i.e. the number of lice on those fish that have lice)

Lice Abundance is defined as the total number of parasites (lice) in a sample of fish divided by the total number of fish in the sample, whether or not individual fish have lice. Mean Abundance is the average of this number over a series of samples (i.e. this is a population estimate of lice numbers in a population of fish that has been sampled)

An extensive marine sampling program has been conducted by Fisheries and Oceans Canada each year from 2003-2008 in the Broughton and Knight Inlet in an attempt to determine the incidence and severity of sea lice infection rates of wild juvenile pink and chum salmon. Total catches of juvenile wild pink and chum were high in 2003, but declined substantially for both species in 2004. Although total catches and catch-per-unit-effort (CPUE) remained relatively constant for both species from 2004 to 2008, the number of fish captured each year varied widely between sampling

locations and between years. In 2008, a total of 622 sets were completed using beach seine and purse seine fishing gear with sampling occurring over 8-10 days each month, near the end of March, April, May and June. In 2008 a total of 22,995 juvenile pink salmon and 9,394 juvenile wild chum salmon were captured, very similar to the number captured in 2007. Only 3,711 sticklebacks were caught in 2008, the lowest number caught between 2003-2008 (A.3).

In 2008, a total of 7,667 pink and chum were frozen and later examined under a microscope for sea lice. There were large variations in both incidence and severity of infection by *L. salmonis* on juvenile pink and chum salmon between years, and also between different locations within any particular year (A.3, A.7).

The prevalence and abundance of *L. salmonis* on juvenile pink and chum salmon has continuously declined since 2004 although the explanations for this decline are not fully understood. The percent of lethally-infected pink salmon was 1.1% in 2005, 0.2% in 2006, 0.2% in 2007 and zero in 2008. In all years, virtually all pink salmon (> 98.9%) sampled from the Broughton Archipelago in late March and early April had a mass less than 0.7 g. By June, the proportion of pink salmon with a mass less than 0.7 g has been less than 1% in all years of the survey. In a controlled laboratory experiment, approximately 35% of 0.3 g pink salmon died following exposure to *L. salmonis* copepodids. Exposures of larger fish showed that juvenile pink salmon are highly resistant to the lethal effects of *L. salmonis* after they grow to a mass of about 0.7 gram. A density of infection of 7.5 lice per gram for pink salmon weighing less than 0.7 g was calculated from the laboratory studies to be the threshold of lethal infection (A.7).

Studies of the development of the sea lice infection on salmon farms in 2005-2007 in the Knight Inlet/ Tribune Channel region indicated that the infection started in the winter. In the winter of 2007/2008 sticklebacks around these salmon farms were heavily (~70%) infected with chalimus stages of *C. clemensi*. The infection occurred throughout the winter and continued after SLICE™ was administered. The prevalence and intensity of the infection before and after the SLICE™ treatment indicated that *C. clemensi* was being continually produced from a source that was not from these farms (A.9).

The Gulf Islands area in the Strait of Georgia is a major rearing area for all species of juvenile Pacific salmon. As part of another study in 2008, we were able to measure sea lice levels on these juvenile salmon. The levels of infection were approximately 70% and were mostly *Caligus clemensi*. There were no salmon farms in the area, indicating that large, natural infections of sea lice can occur in the absence of farms (A.9).

Sea Lice Management and Transmission

A mathematical framework was used to connect data from farms with data from wild salmon. It was found that SLICE™ reduces lice on farms and therefore transmission to wild juvenile salmon. Reduced sea lice transmission implies improved wild salmon survival but it remains unknown if SLICE™ is sufficient to conserve and restore wild salmon (A.4).

Studies of the development of the sea lice infection on salmon farms in 2005-2007 in the Knight Inlet/ Tribune Channel region indicated that infections

begin in the winter. In the winter of 2008, salmon farms at the Knight Inlet/Tribune Channel region were treated with SLICE™ and thus were virtually free of sea lice. In the winter of 2007/2008 sticklebacks around these farms were heavily (~70%) infected with chalimus stages of *C. clemensi*. The infection occurred throughout the winter and continued after SLICE™ was administered. The prevalence and intensity of the infection before and after the SLICE™ treatment indicated that *C. clemensi* was being continually produced from a source that was other than the salmon farms (A.9).

Plankton Monitoring

Abundance and spatial distributions of planktonic stage sea lice were mapped based on results of biweekly net tow surveys carried out in late winter-spring of 2007 and 2008. The abundances of nauplior and copepodid stages of both *Lepeophtheirus salmonis* and *Caligus clemensi* were low (always less than 0.5 m^{-3}, *L. salmonis* average 0.005 m^{-3} for nauplii, 0.03 m^{-3} for copepodids). *L. salmonis* were found to be most abundant near recently active fish farms while *C. clemensi* showed little or no spatial association with fish farms, but may have been associated with herring aggregations. The abundance and occurrence rates of planktonic *L. salmonis* appeared to lag behind sea lice egg production on nearby farms by up to 2 weeks for nauplii and up to 4-6 weeks for copepodids (A.5)

Diel Migration of Lice and Relationship to Fish Location

In the absence of fish hosts, there does not appear to be a preference for any particular depth in the vertical distribution of *L. salmonis* nauplii and copepodids and under these circumstances there is no apparent effect of daytime period on the vertical distribution of lice larvae (A.6).

In the absence of lice, juvenile pink salmon distribution changes slightly from day to night and fish less than 3 weeks post-saltwater entry (up to ~0.5 g) are typically found within the top 3 m of the water column. In the presence of lice, juvenile pink salmon were found to have a more dispersed vertical distribution during the day, but no change in distribution was seen at night. No difference in the proportion of infected vs. uninfected fish was observed relative to the vertical distribution of the fish, suggesting that infective pressure is independent of daylight and depth. It is unknown whether the copepodids were following the fish or the fish were following the copepodids, only that their vertical distributions were correlated within the column when they were free to interact (A.6).

Impacts of Lice on Salmon – Laboratory and Field Studies

Experiments in 2008 involved over 10,000 juvenile pink salmon, some as small as 0.2 g, and examined, in a field setting, the effects of sea lice (*L. salmonis*) on ionic balance and swimming performance of the fish at sea lice densities of 1 to 3 lice per fish. Sub-lethal effects of 1 louse per fish on ionic balance and swimming performance were dependent on the size of the fish but significant effects occurred only on fish with a body mass of <0.5 g. A higher density of lice (2 or 3 lice per fish) was required to trigger sub-lethal effects on ionic balance and swimming performance

in larger fish (0.5 – 3.7g). In all cases, sub-lethal effects were only detected when the life stage of the louse was at least chalimus 3-4. Compared with the sub-lethal changes observed for <0.5 g fish with 1 louse per fish, increasing lice density up to 3 lice per fish did not have an additive sub-lethal effect for fish of any size (B.1-5).

Artificially infected fish appeared to be more sensitive to sea lice load than were ocean-caught fish that already possessed a sea lice load. In all physiological studies mortality was minimal (<2%) among fish infected with sea lice during tests that lasted up to 28 days (B.1-5).

Fish health

Juvenile pink salmon out-migrating through the Broughton Archipelago in 2008 were evaluated for physiologic condition, sea lice, other parasites, bacteria, viruses, and microscopic lesions. Juvenile pink salmon collected directly from the Glendale River in March 2008 had no sea lice or microscopic lesions (by histopathologic examination), suggesting that all lesions in fish sampled from salt water developed after saltwater entry. Hepatocellular lesions in fish increased in prevalence from undetectable in March to 40% in June. Acute liver lesions (hepatocellular hydropic degeneration) affected more fish in May 2007 (32%) than in May 2008 (4.1%); these lesions in 2007 might be related to poor adult returns in 2008. Sea lice were associated with hepatocellular changes in 2008, but not in 2007 (B.5).

Sea lice (motile or non-motile - either *Caligus clemensi* or *Lepeophtheirus salmonis*) were found on 10.9 % (73/669) of the juvenile pink salmon sampled. The highest sea lice prevalence occurred in June 2008. The fish ranged in size from 2.9 cm to 10.8 cm (mean length 5.5cm) and condition factor was not found to be significantly associated with sea lice (B.5).

Parasites belonging to several taxonomic groups infested juvenile pink salmon, in many cases at higher prevalence levels than sea lice (B.5).

Salmon Population Dynamics

Pink salmon production out of the Glendale Channel was approximately half of that of 2007 and is likely attributed to low adult escapement in 2007 relative to higher numbers observed in 2006. A total production estimate of approximately 15 million pinks from Glendale was estimated through a combination of channel marking and subsequent recapture at a down stream fish-wheel (C.1-2).

Installation of a resistivity counter on the Glendale spawning channel will allow us to determine accurate egg to fry survival numbers, but multiple years of this work will be required to assess the survival trend over time. Continuation of the Glendale juvenile program and expansion of similar juvenile projects (i.e. Viner Creek) both in enumeration and assessment of primary productivity in the early marine residence of these fish is considered to be of importance. (C.1-2)

Preliminary estimates of escapement derived via over-flight assessments indicate replacement of brood in some systems and much reduced returns relative to brood in other systems. The overall trend in escapement indicates a significant decrease in overall numbers between 2006 and 2008 with the Glendale at 91% fewer numbers of returning adults than in 2006. The trends are similar to those ob-

served in other systems outside of the Mainland Inlets (i.e. Central and North Coast) and do not appear to be a localized event as was encountered in 2002 and 2003 (C.1-2).

Salmon/Lice Dynamics in Regions Outside the Broughton Archipelago

Juvenile salmon in the Bella Bella region, an area that lacks salmon farms, host low levels of sea lice (3.5%) and these are considered to be natural background levels in this region. In regions where there are fish farms, significantly more juvenile salmon are found to host sea lice in areas near to farms (< 1 km) compared to areas farther from farms (> 1 km): Klemtu 21.8% near, versus 3.6% further away; Discovery Islands 37% near, versus 26.8 % further away. Elevated levels of lice nearer to farms included significantly greater proportions of *L. salmonis*, a salmon-specific species, than *C. clemensi*, which is more of a generalist (found on numerous fish species) (C.3).

The Kitasoo Fisheries Program undertook a monitoring program and collected juvenile salmon in areas around salmon farms and in areas away from farms between 2004 and 2008 and assessed them for sea lice. Both *C. clemensi* and *L. salmonis* were observed on fish in all areas sampled. In 2008, lice levels were the lowest of all years data were collected. Prevalence (<10%) and intensity (<1.5) of *L. salmonis* was low in all areas sampled and in all years examined for both chum and pink salmon. *L. salmonis* abundance levels were higher on pink salmon caught around farms in 2005 and 2006 but not in 2007 or 2008 when data were compared to the reference area (D.1).

The Gulf Islands area in the Strait of Georgia is a major rearing area for all species of juvenile Pacific salmon. As part of another study in 2008, researchers were able to measure sea lice levels on these juvenile salmon. The levels of infection were approximately 70% and were mostly *C. clemensi*. There were no salmon farms in the area, indicating that large, natural infections of sea lice can occur (A.9).

The preceding summary of key points represents information consolidated from the findings of each of the research groups. The full research summaries are found in the following section of the 2008 Summary of Interim Research Findings. The research summaries represent the views of the individual scientists and may not reflect those of the Forum or the Science Advisory Council. The data are preliminary and findings and conclusions have not been peer reviewed.

3C – SUMMARY OF 2007 INTERIM RESEARCH FINDINGS

The 2007 research program resulted in a large amount of data and some key findings from each study are highlighted below. These points have been examined and approved by the Science Advisory Council. It is important to note, however, that the following information is based on preliminary reports of projects that have not been subject to formal peer review. The key points, denoted in parentheses, are attributed to individual projects in the reports section 2007 Summary of Interim Research Findings.

Oceanography

To better understand the dynamics of the nature of the aquatic environment in the Broughton and provide insights into the distribution of fish and lice, oceanographic data have been gathered by several of the research groups. These data indicate that there is a considerable degree of wind-driven surface water circulation that may result in surface transport in directions counter to residual tidal currents (estuarine circulation) in the Broughton Archipelago (A1). Although near surface currents are predominantly seaward, winds have the ability to drive surface water (and potentially any particulates, including sea lice, contained in these surface waters) up the inlet contrary to current flow (A1). Circulation models are being developed to simulate specific time periods to be evaluated through comparisons with observed currents.

Comparisons of data collected from 2003 to 2006 indicate that lice abundance, surface water salinity and surface water temperature were all greater in 2004 compared to other years (A3).

Surface water temperature increased (from 8.5°C to 12.5°C) and surface salinity decreased (from 26 ppt – 19 ppt) between April and June of 2007 (B1-4).

Natal Origins of Juvenile Pink and Chum Salmon

Fish samples have been collected and are being processed to determine if otolith chemical composition signatures can be used to determine the natal streams of origin of juvenile fish that are sampled while migrating through the Broughton Archipelago (A2). Data are not available at this time.

Sticklebacks

In 2007 sticklebacks were captured in large numbers during juvenile salmon fry sampling and numbers were high relative to previous sampling years (A3). In many cases the sticklebacks were more heavily infested by lice than the juvenile pink and chum salmon captured in the same sets (A3).

New data were obtained that demonstrate behavioural interactions between sticklebacks and juvenile Pacific salmon. When maintained in a tank enclosure, sticklebacks were observed cropping egg strings from gravid females on juvenile salmon, and sometimes actively removing adult lice. Sticklebacks preferred female sea lice over males and gravid females were preferred to non-gravid females. In other experiments, adult lice showed no preference between water conditioned by sticklebacks or salmon, but did show a preference for water that had contained fish compared to water that had not (5A).

Marine Monitoring of Juvenile Pink and Chum Salmon and Sea Lice

DEFINITIONS

Prevalence is defined as the number of cases of a disease or parasite found, divided by the number of subjects examined. (i.e. the number of fish with lice/ the number of fish examined)

Lice Intensity is defined as the total number of lice collected divided by the number of fish with an infestation. (i.e. the number of lice on those fish that have lice)

Lice Abundance is defined as the total number of parasites (lice) in a sample of fish divided by the total number of fish in the sample, whether or not individual fish have lice. Mean Abundance is the average of this number over a series of samples (i.e. this is a population estimate of lice numbers in a population of fish that has been sampled)

A comparison of sampling methodologies for fish and lice identification and quantification performed by two different investigation teams resulted in almost complete agreement in findings (A3 & A4). There was variation between research groups in the prevalence and intensity of lice observed on wild pink salmon captured in the Broughton Archipelago in 2007. Lice levels were low early in the season (March - April) and increased as time progressed (April – June). Overall, the prevalence of lice on juvenile pink salmon (~0.3 g) was described as being low relative to other years.

One study (A3) found that the overall prevalence and abundance of sea lice was low in 2007 relative to other years, approximately 80% of all juvenile pink and chum salmon (n=8,331, 0.3g – 5.1 g) had no lice (i.e. prevalence was approximately 20%). Note that this statistic summarizes the overall infection rate (prevalence) observed for all pink and chum salmon caught during the March–June period in 2007, and includes fish captured close to and distant from salmon farms. Juvenile chum salmon appeared to be more heavily infected than other species in all years examined.

A second study (n=913 fish, 0.2 g – 3.1 g) found similarly low lice prevalence (<25%) (B1-4). Lice abundance was between 1.0 and 1.3, translating to between 0.24 and 0.81 lice per gram of fish.

A third study sampled 302 fish (0.1 g – 5.9 g) for a health survey and found a 31% lice prevalence (all stages) (B1-4). Of the 23 fish that had visible skin damage, 14 had attached sea lice stages; 2 had only motile stages and 7 had no lice. Forty-one fish (13.6% prevalence) had motile stages of lice present. Intensity, prevalence and density of lice were observed to be slightly greater in May than in other sampling months. At this time approximately 50% of the attached lice at all 3 sampling sites were identified in the lab as *Caligus clemensi* copepodid or chalimus stages.

In a fourth study, prevalence of sea lice on juvenile pink and chum salmon in the Bella Bella region, which has different environmental conditions from the Broughton Archipelago and no fish farms, averaged 4.2% (n=2,071, 0.35 g to 2.64 g) (C3). Lice were slightly more prevalent on chum than pink salmon (4.5% vs. 3.8%) in this area. Escapement counts and returns are being examined for any relationships between lice prevalence and adult salmon returns.

Additionally, during survival experiments, abundance of lice on wild caught fish was generally less than one per fish; chalimus and copepodids declined over 20 days and motiles rarely exceeded 0.4 lice per fish over 20 days (B5).

Fish sampling was performed with respect to distance from salmon farm cages to estimate the transmission of sea lice from farm to wild juvenile salmon, but the data have not yet been analyzed (A4).

Plankton tows were performed in an attempt to identify distribution patterns of planktonic lice in a region of the Broughton. The majority of early samples (Feb – March) contained no lice. While larvae were relatively rare, *Caligus copepodids* were found in higher abundance in side inlets and the low salinity areas. *Lepeophtheirus copepodids* were most abundant near active farms (A5). Sampling tows in April were hampered by dense plankton blooms which congested the sampling nets and precluded further sampling. Equipment designed to examine the vertical distribution of sea lice larvae in the water column has been built and tested in local waters. (A6) This equipment will be used to investigate salinity and temperature preferences of lice larvae in the Broughton Archipelago as well as diel (i.e. daily) migration in 2008.

Impacts of Lice on Salmon – Laboratory and Field Studies

Wild pink salmon (0.2-2.0 g) were successfully transferred to and raised in the laboratory at a salinity of 28 ppt. They displayed growth patterns similar to those observed in the Broughton Archipelago (B1-4 & B5). Wild fish that arrived in the laboratory with existing lice infestations lost these lice within 1 – 2.5 weeks following collection (B1-4). A separate study also found that lice infestations disappeared over approximately two weeks when fish were held in tanks in field locations in the Broughton Archipelago (B5).

In the laboratory, repeatable methods of measuring swimming performance were developed and provide new data for juvenile pink salmon against which field-collected data may be compared. When fish (1.6 g and 3.0 g) with 1 louse were compared with fish having no lice, maximum swimming performance was statistically indistinguishable. Louse stage (at 1 louse per fish) had no apparent effect on maximum swimming performance. The applicability of these results to conditions in nature will be tested in the field in 2008 (B1-4). Uninfected juvenile fish were challenged with ionic (salinity) variation over an 11-day period. It was hypothesized that as salinity increases so would gill enzyme activity and drinking rate in an attempt to maintain ionic and osmotic homeostasis. Experimental data show this to be true (B1-4).

Copepodids were artificially raised from egg strings and were successfully used to infect juvenile pink salmon (0.9 g) in the laboratory. Duration of survival of juvenile salmon decreased with increasing lice loads, but this effect was statistically supported only when lice loads were an order of magnitude (10-times) greater than levels reported in nature (B1-4). Even so, mortalities of pink salmon spiked when lice entered a moulting stage of their development (B1-4).

A physiological model is being developed to calibrate fish health with survival and fitness to attempt to determine at what point a fish becomes compromised

by sea lice. The model is currently being calibrated using laboratory data (B1-4).

Juvenile pink salmon from all Broughton Archipelago sample sites gained weight and length between April and June. Condition factor (one measure of the physical condition of fish that describes the relationship between body weight and body length), was significantly associated with sampling month, while presence or absence of sea lice and sea lice density (lice/g of fish) were not significantly associated with condition factor in any of the general linear models tested (B1-4).

Skin lesions and lower liver glycogen stores were associated with the presence of sea lice. No other health parameters (i.e. condition factor, histopathological findings, and viral and bacterial infections) were apparently associated with sea lice (B1-4).

Based on histological studies, fish first entering the saltwater environment appeared healthy. A portion of those fish sampled one month later displayed lesions on the liver consistent with toxicants. There was a positive correlation between some liver lesions and a myxosporean parasite (25% of fish were infected with the myxosporean). In no cases were the liver lesions or the myxosporean infections correlated to lice infestation (B1-4).

Another study examined the impact of sea lice on schooling behavior of juvenile pink salmon in tanks in the field in the Broughton Archipelago (B5). Although the data are not yet available, some preliminary findings suggest that predation may occur selectively on lice infected prey but further analysis and modeling, however, is necessary to substantiate these results and to more thoroughly evaluate what the implications are for sea lice and salmon population dynamics.

Salmon Population Dynamics

The overall catch of juvenile salmon in the Broughton Archipelago, for sampling purposes in 2007, was described as being the lowest over the last five year period of monitoring (despite an increase in the number of sampling sites) and with a greater size variation than previously observed (A3).

Freshwater counts from a variety of systems, and migratory patterns of adult and juvenile (Glendale) salmon were tracked through the installation of video equipment (Embley River) and acoustic counter (Glendale), aerial surveys, and fry traps (C.1-2).

The 2007 pink adult salmon returns (escapement), as a whole in the mainland inlets of the Broughton Archipelago system are described as being similar or slightly improved relative to the brood return in 2005 (C.1-2).

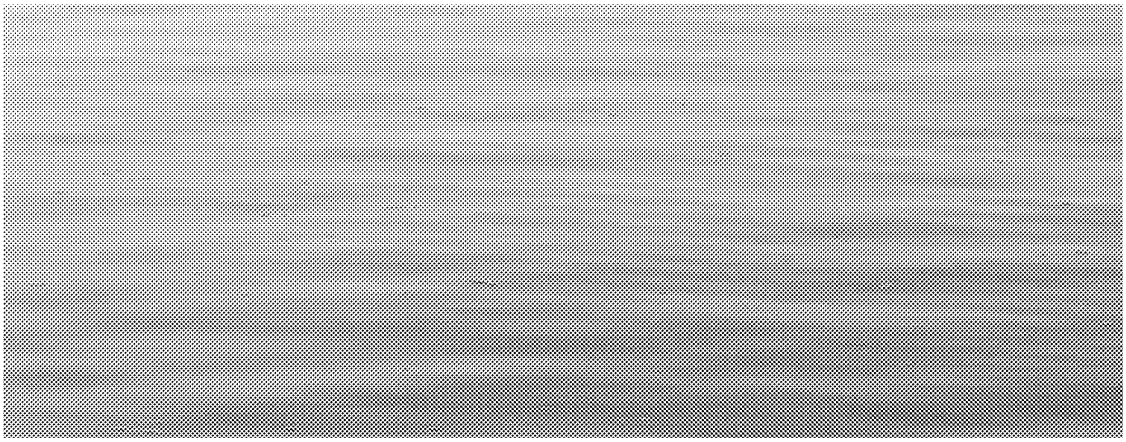
2007 fry out-migration from the Glendale River spawning channel was estimated at 7.7 million pink fry and 34,000 chum salmon fry. Fry appear to have migrated out later in 2007 than in past years (C.1-2).

Migratory patterns of sockeye salmon were studied in the Skeena River system and it was suggested that if salmon farms were to be situated in this general area, they should be positioned to minimize interactions between wild and farmed salmon (5B).

In a study of Fisheries and Oceans Canada hatchery fish in the Campbell River area, natural fluctuations in phytoplankton and zooplankton populations may

be used as a gauge for prey availability and optimal release timing for artificially reared coho salmon (50).

The preceding summary of key points represents information consolidated from the findings of each of the research groups. The full research summaries are found in the following section (Section 4) of 2007 Summary of Interim Research Findings. The research summaries have been edited and approved by each of the researchers and no editing of their final summaries has taken place. The research summaries represent the views of the individual scientists and may not reflect those of the Forum or the Science Advisory Council. The data are preliminary and findings and conclusions have not been peer reviewed.



APPENDIX 4 - COMMISSIONED RESEARCH & TECHNICAL REPORTS

Please see www.pacificsalmonforum.ca to view the following reports:

Summary of 2008 Interim Research Findings

Summary of 2007 Interim Research Findings

Nowhere to Hide – Salmon versus People in the 21st Century (Dr. Brian Harvey)

Broughton Archipelago: A State of Knowledge (Dr. Isobel Pearsall)

Science and Sea Lice – What Do We Know, February 22, 2008 (Dr. Brian Harvey)

A Review of Research Priorities on Sea Lice, Wild Salmon and Farmed Salmon Interactions (Dr. Bill Pennell, Dr. Paige Ackerman)

Protocols and Guidelines – A Reference Manual for Research Involving Wild/Cultured Fish Interactions with Sea Lice (Dr. Anthony Farrell)

Please note: The following report is scheduled for release in February 2009 and will be posted in electronic form when available:
Science and Sea Lice – What Do We Know – An Addendum February 2009 (Dr. Brian Harvey)

APPENDIX 5 - FORUM REPORTS & TECHNICAL REVIEWS

Please see www.pacificsalmonforum.ca to view the following reports:

Annual Report 2008

Annual Report 2007

Annual Report 2006

Interim Report to Government, June 2007

Thinking Like a Watershed

Review of British Columbia's Statutes and Regulations Affecting Wild Salmon Management

Data Sharing Agreement and Communications Protocol

Review of BC Finfish Aquaculture Regulation – A Progress Report

BC Pacific Salmon Forum Research Framework

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