The Assessment and Planning Project
BC Case Report No. 2

The Salmon Aquaculture Review

Facing ecological complexity and scientific uncertainty in the first policy level assessment under British Columbia's *Environmental Assessment Act*

by

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August 1999

The Assessment and Planning Project

Over the past decade or so, several Canadian jurisdictions have moved to integrate environmental considerations more effectively in land use planning. Many of the most promising initiatives have been in the southern parts of Ontario and British Columbia, which are enjoying and suffering significant population increases and associated urban pressures.

Government authorities and citizens in these two areas have used many different approaches to manage growth and improve environmental sensitivity. Relevant initiatives have involved use of strategic environmental assessments or explicit use of environmental assessment principles and obligations in special planning and growth management regimes or in consensus-based multi-stakeholder co-operation efforts. Some have been driven by provincial action; others have been led by community groups and local citizens. Some reflect a larger vision of progress to sustainability; others were begun in response to pressing immediate problems and with understandably limited attention to overall implications.

The Assessment and Planning research project, funded by the Social Sciences and Humanities Research Council of Canada, seeks to compare and learn from experiences in the two provinces. Part of the work centres on a series of case studies covering a range of initiatives in the two provinces. *The Salmon Aquaculture Review: facing ecological complexity and scientific uncertainty in the first policy level assessment under British Columbia's Environmental Assessment Act* is the report on the second British Columbia study. For other case studies and publications of the project, contact the project coordinator and editor of the case study series, Dr. Robert Gibson, Department of Environment and Resource Studies, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1.

The *Salmon Aquaculture Review* study

This case report examines the first "strategic" level assessment under the British Columbia *Environmental Assessment Act*. Section 40 of the BC law goes beyond the individual project focus of most environmental assessment processes to provide for broader assessment of "processes, practices and procedures" applied under other legislation, including approaches to regulating whole industries. The Salmon Aquaculture Review, concluded in 1997, assessed the controversial farming of salmon, usually exotic Atlantics, in open netcages along the BC coast. Concerns addressed by the review included escapes of Atlantic salmon and subsequent competition with or genetic impacts on indigenous salmon, transfer of diseases from farmed salmon to wild salmon, effects of wastes from farming operations, and the killing of marine mammals and birds in efforts to protect farmed salmon from predation.

This case report on the Salmon Aquaculture Review gives particular attention to challenges arising from ecological complexities, data limitations, conventional and unconventional information sources, and competing options for dealing with the resulting uncertainties. It finds that while the Review was a significant step forward for environmental assessment and informed public policy debate, it had some significant limitations. The narrow terms of reference, weak base of anticipatory research, and limited application of the precautionary principle are matters worthy of correction in future strategic level assessments.

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Carla Davidson

Introduction

Salmon aquaculture in British Columbia is a young and controversial industry. Since the early 1980s it has expanded significantly, suffering growing pains including environmental concerns arising from early experimentation in siting and husbandry. Current aquaculture practices still deposit tonnes of fish faeces and feed as wastes, allow farmed salmon to escape, involve the killing of marine mammals, and create the potential for transfer of diseases from farmed to wild stock.

In 1995 the provincial government asked its Environmental Assessment Office to perform an assessment of the regulatory framework guiding salmon aquaculture. The resulting Salmon Aquaculture Review was initiated under section 40 of the BC *Environmental Assessment Act.* Section 40 goes beyond the individual project focus of most environmental law to provide for policy level or "strategic" assessment of "processes, practices and procedures" applied under other legislation, including approaches to regulating whole industries.[1]

The Salmon Aquaculture Review was the first use of section 40 and faced predictable problems in, for example, the definition of the assignment in the terms of reference and in the establishment of suitable research, review and decision-making rules and processes. These difficulties were increased by the complexities of the case. Salmon aquaculture raised a range of ecological and community concerns for which no easy technical resolution was likely, and the review participants faced a set of fundamental issues common to cases of decision making in face of complexity and uncertainty:

- how to do a reliable assessment with limited baseline data and few directly relevant scientific studies;
- how to decide what information about ecological harm would be accepted as appropriate evidence;
- how to interpret and apply the precautionary principle;
- how to satisfy the *Environmental Assessment Act's* commitment to sustainability; and
- how to balance desires for substantive and procedural clarity in an unprecedented assessment that needed also to learn as it went and adapt its approaches accordingly.

The Salmon Aquaculture Review did not confront all of these issues explicitly and its implicit positions were not entirely consistent. Nevertheless, the Review stands as a valuable example of what can happen while wrestling with complexity and uncertainty in

[1] British Columbia *Environmental Assessment Act,* 1994. Section 40(1).

a policy or strategic level assessment under BC law. It may also indicate what is likely to happen in similar future cases.

This case report focuses on how the Salmon Aquaculture Review dealt with uncertainty and complexity. The intent is to see if direct attention to these matters may reveal useful lessons for future assessments and for other efforts to integrate environmental considerations more effectively into planning for new and continuing undertakings in BC and elsewhere.[2]

Concerns about Salmon Aquaculture

Atlantic salmon is the most common farmed species in BC. In the early days of the industry Chinook salmon were farmed, but because Atlantic salmon are more marketable and can be stocked at higher densities, the industry shifted to farming Atlantics. By 1994, 70 percent of salmon farmed in BC were Atlantic salmon.[3] These salmon can, and do, escape from the netcages where they are raised, creating the possibility that this non-native species could establish in west coast rivers. Because the industry has had to import eggs to stock their farms, there is also concern that imported stock could introduce exotic diseases or new strains of existing diseases.[4] This concern was brought to the fore for many Broughton Archipelago residents in 1991 when it was alleged that managers of a local salmon farm had stocked their farm with salmon that carried a strain of furunculosis that was transferred to wild coho salmon.

The Broughton Archipelago case exemplifies the complexity and uncertainty inherent in discussing the ecological effects of salmon farming. In 1991, shortly after the introduction of smolts infected with furunculosis into an Archipelago salmon farm, two nearby salmon enhancement facilities found their fish dying from the same disease. Prior to this infection, the facility's annual mortality rate had averaged 3 percent for nine years. In 1991, 28 percent of the broodstock died and 37 percent died the year after.[5]

In 1993, two salmon farms not far from a salmon enhancement facility (a hatchery for indigenous salmon used to supplement wild stocks) stocked their netcages with Atlantic salmon imported from a hatchery that was infected with *Aeromonas salmonicida*, the

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[2] The methodology for this study involved two main components. First, a literature review of material from or about the Salmon Aquaculture Review was completed, including material in the Salmon Aquaculture Review project registry in the Environmental Assessment Office. Second, this literature review was augmented by interviews with fifteen key informants, all of whom were participants in the Salmon Aquaculture Review. The interviewees included three members of the Review's Technical Advisory Team, one member of the Review Committee, three Environmental Assessment Office staff involved in the review, one other provincial government official, one federal government official, three individuals from non-government organisations that made submissions to the review, and one independent researcher. A list of the interviewees is provided at the end of the report.

[3] Salmon Aquaculture Review, 1997. *Summary Report*. Chapter 2: The Salmon Aquaculture Industry. Environmental Assessment Office, British Columbia. http://www.eao.gov.bc.ca/project/aquacult/salmon/report/V1chp2.htm

[4] David Ellis and Associates, 1996. *Net Loss: The Salmon Netcage Industry in British Columbia.* Report to the David Suzuki Foundation, Vancouver, B.C.

[5] Morton, Alexandra, 1997. *The Introduction of Diseased Atlantic Smolts into the Broughton Archipelago: A Tale of Two Epidemics.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review. Project Registry no: 000522.

causative agent for furunculosis. A few months after these fish were introduced into the salmon farms the neighbouring enhancement facility lost 47 percent of its broodstock to furunculosis. This raised suspicion that the disease had been transferred by infected fish that escaped from the salmon farm netcages. Further investigation revealed that the disease strain in the original hatchery was resistant to all three antibiotics approved for use against furunculosis while the enhancement facility furunculosis was resistant only to one of the antibiotics – oxytetracycline. On the surface the different resistance patterns suggest different disease sources, but the evidence is inconclusive since the fish populations were tested at different times and resistance patterns can change quite quickly.

In August 1994, 20,000 diseased fish escaped from the farm just before 95 percent of the wild salmon returning to spawn in the Fraser River watershed came through the Queen Charlotte Strait. Tens of thousands of expected sockeye did not reach the Fraser. It is not known and perhaps impossible to prove whether or not the sockeye had died of furunculosis caught from the escaped Atlantic salmon. However, the sockeye loss coincided with a drop in chinook populations in the Archipelago and all age classes of the chinook disappeared simultaneously, suggesting that an infectious agent rather than an ecological factor caused the decline.[6]

Department of Fisheries and Oceans scientists attempted to determine the source of the infection in the salmon enhancement facility. They found no conclusive scientific evidence that the events in this account were related or that the imported Atlantic salmon introduced a strain of furunculosis that decimated the chinook stocks in the Archipelago.[7] However, there is also no conclusive evidence that these events are unrelated or that the imported fish did not seed disease in native stocks.

Among coastal residents in BC, these events deepened concerns about the environmental impacts of salmon farming. By the mid-90s, when the Salmon Aquaculture Review was initiated, the main worries fit in four categories: escapes of Atlantic salmon and subsequent competition with or genetic impacts on indigenous salmon, transfer of diseases from farmed salmon to wild salmon, effects of wastes from farming operations, and the killing of marine mammals and birds in efforts to protect farmed salmon from predation.

Escapes

Farm fish escape from netcages that wear out or are torn by predators, vandals or storms. By law, escapes must be reported and between 1987 and 1996 BC salmon farms reported that approximately 1,078,368 salmon had escaped. This likely understates the reality. If unreported escapes and what the industry and assessment documents call "leakage" were included, the total might be double the reported level.[8]

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[6] Morton, Alexandra, 1997. *The Introduction of Diseased Atlantic Smolts into the Broughton Archipelago: A Tale of Two Epidemics.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review. Project Registry no: 000522.

[7] Personal communication with project interviewee, February 1998.

[8] Alverson, Dayton, L. and Ruggerone, Gregory, 1997. *Escaped Farm Salmon: Environmental and Ecological Concerns.* Salmon Aquaculture Review Technical Discussion Papers, vol. 3, part B.

The large numbers of escaped Atlantic salmon have led to fears that these fish are competing with native Pacific salmon. Steady escapes represent constant recruitment of Atlantic salmon into the ecosystem resulting in steady competition with the native salmon stocks.[9] In 1995 the Atlantic Watch Program found that 92 percent of reported Atlantic salmon sightings and landings were in the Johnstone Strait, which is a critical migratory route for Fraser River sockeye, an important commercial fish.[10] There are also fears that escaped Atlantics may establish breeding stocks in west coast streams and drive out the native fish. In August and September 1998, twelve Atlantic salmon were found in the Tsitsika River on Vancouver Island. Tests suggested that the Atlantic salmon were of wild origin, meaning that they had been spawned in the river by escaped Atlantics.[11] This incident, which represented the first documented case of Atlantic salmon breeding in BC's rivers, intensified concern over establishment of Atlantic salmon in BC.

Disease

The furunculosis cases discussed above have contributed to a broader set of worries that imported salmon eggs may carry with them new diseases and different strains of Pacific diseases that could spread from caged stock to wild stock, decimating wild populations which have no natural immunity from these pathogens. No issue is more shrouded with uncertainty and disagreement among scientists than the issue of disease transference. Most evidence for transference is anecdotal, but still the cause for great concern, as is illustrated by the case in the Broughton Archipelago.

The jammed, stressful conditions within a netcage are known to encourage the spread of disease.[12] Whether disease in farmed fish raised in netcages threatens wild stocks in BC is harder to assess. However, Atlantic salmon smolts imported into Norway in 1989 introduced the parasite *Gyrodactylus salaris*.[13] By 1992, the parasite was recorded in 37 rivers and 36 hatcheries and decimated natural populations of wild salmon. To stop the spread of the disease, Norway initiated a control programme that involved poisoning whole rivers to wipe out infested populations.[14]

To prevent and treat disease in farmed salmon, managers use pesticides, medicated feed and a number of vaccines, though as vaccines improve, the use of medicated feed lessens.[15] Residues from pesticides and medicated feed may remain in the marine

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[9] Georgia Strait Alliance, 1997. *Err on the Wild Side.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review.

[10] Georgia Strait Alliance, 1997. *Err on the Wild Side.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review.

[11] Department of Fisheries and Oceans. "Atlantic Salmon in the Tsitsika River." Backgrounder. 23 December, 1998.

[12] Stephen, Craig and Iwama, George, 1997. *Fish Health.* Salmon Aquaculture Review, vol. 3, Technical Discussion Papers, part C.

[13] Note that the incident in Norway was caused by the importation of salmon smolts. In BC, only surface-disinfected fertilized eggs are imported and the importation of smolts is illegal to prevent a similar occurrence.

[14] David Ellis and Associates, 1996. *Net Loss: The Salmon Netcage Industry in British Columbia.* Report to the David Suzuki Foundation, Vancouver, B.C.

[15] Personal communication with project interviewee, February 1998.

environment and enter tissues of benthic organisms.[16] Questions remain about the ability of bacteria to evolve antibiotic resistance in response to heavy applications of antibiotics, and whether antibiotic residues in human food may affect human health.[17] Along with medicated feeds and pesticides, fish farms along the coast release tonnes of waste in fish faeces and wasted feed. If the farm area is poorly flushed, this waste may suffocate benthic communities, or contribute to hypernutrification, which in turn encourages toxic algal blooms.[18]

Wastes

People relying on coastal resources, especially those within First Nations communities, are particularly concerned about the effects of wastes on marine resources such as shellfish and benthic communities.

Salmon farms deposit wastes as fish faeces, uneaten feed, and to a lesser extent, human wastes and litter. Uneaten feed may contain antibiotics, whose possible impacts on the benthic community are unknown.[19] In sites that are poorly flushed, organic wastes may accumulate and initially enrich the seafloor below the cage. If accumulation continues and the sediments cannot absorb the nutrients, then anoxia and the production of hydrogen sulphide and methane can occur.[20] Also, sedimentation from the farm can smother benthic organisms. Currently, the accumulation of wastes is managed by siting farms in areas with suitable currents, and allowing the seafloor to recover during fallow periods.[21]

Predator control

Marine mammals attracted to the concentration of penned-in fish are sometimes shot to reduce predation losses. Dogs, shooting and anti-predation netting kill many seals, herons, sea otters and sea lions daily. One farm manager reported that over the past four years, at one farm, 431 seals, 38 otters, 16 herons, 29 sea lions, an osprey and a porpoise had been killed.[22]

Acoustic deterrent devices (underwater noise generators) are used to scare away predators. They not only disturb the farm's neighbours, but also lose their effect as animals become used to the noise, or deaf, and resume their predation of caged salmon.[23]

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[16] Iwama, George, *et al*. 1997. *Aquatic Mammals and Other Species.* Salmon Aquaculture Review, vol. 3, Technical Discussion Papers, part E.

[17] The David Suzuki Foundation. "Salmon Farming Industry Threatens B.C.'s Wild Fish Stocks" News release, 24 October 1996.

[18] Burd, Brenda, 1997. *Waste Discharges.* Salmon Aquaculture Review, vol. 3, Technical Discussion Papers, part D.

[19] Burd, Brenda, 1997. *Waste Discharges.* Salmon Aquaculture Review, vol. 3, Technical Discussion Papers, part D.

[20] Burd, Brenda, 1997. *Waste Discharges.* Salmon Aquaculture Review, vol. 3, Technical Discussion Papers, part D.

[21] Burd, Brenda, 1997. *Waste Discharges.* Salmon Aquaculture Review, vol. 3, Technical Discussion Papers, part D.

[22] Georgia Strait Alliance, 1997.

[23] Iwama, George, *et al*. 1997. *Aquatic Mammals and Other Species.* Salmon Aquaculture Review, vol. 3, Technical Discussion Papers, part E.

The noise also interferes with animal communication signals and may drive away migrating whales and porpoises.[24] The overall effects of these practices on coastal populations of marine mammals, birds and other species are unknown.

Government Responses and the Salmon Aquaculture Review

As early as the mid-1980's, members of the public, First Nations and environmental groups wrote the government and voiced concerns about aquaculture. In 1986 the province declared a moratorium on new salmon farms and launched the Gillespie Inquiry.[25] This inquiry made a number of recommendations to protect the environment and increase First Nations involvement. The Ministers' Aquaculture Industry Advisory Committee was created to advise the government on development of the industry. The government also initiated the Coastal Resources Inventory Studies (CRIS) to "identify and attempt to address the causes of local conflict."[26] All conflict was not resolved by the CRIS, so in 1988 the BC Ombudsman's office presented a report detailing the need for integrated resource planning, dispute resolution and administrative fairness.[27]

In the early 1990's husbandry changed from the raising of chinook salmon to Atlantic salmon and concerns regarding escapes and disease transfer intensified. During the mid 1990's the BC Ministry of Agriculture Fisheries and Food, the BC Ministry of Environment, Lands and Parks and the federal Department of Fisheries and Oceans conducted an in-house exercise to deal with issues regarding the policy framework guiding salmon aquaculture. They proposed an action plan that included a moratorium on new salmon farming licences and an environmental assessment of the policy framework guiding salmon aquaculture.[28]

In April 1995 the government declared the moratorium on new salmon farming licences and asked the Environmental Assessment Office to perform an assessment of the policy framework for the salmon aquaculture industry under section 40 of the BC *Environmental Assessment Act.*[29] This section allowed the Environmental Assessment Office to assess the "methods in use under the other enactment for the prevention or reduction of adverse effects" and "any other processes, practices and procedures in use under the other enactment"[30] for their ability to mitigate and prevent adverse environmental impacts. This first use of the *Environmental Assessment Act* for a "strategic" rather than project level assessment required the Environmental Assessment Office to review the whole legislative regime involved in managing salmon aquaculture for its impacts on the environment.

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[24] Iwama, George, *et al*. 1997. *Aquatic Mammals and Other Species.* Salmon Aquaculture Review, vol. 3, Technical Discussion Papers, part E.
[25] Gillespie, David. *An Inquiry into Finfish Aquaculture in British Columbia: Report and Recommendations.* 12 December 1986, Victoria, BC.
[26] Salmon Aquaculture Review, 1997. *Summary Report*.
[27] Owen, Stephen. Office of the Ombudsman. 1988. *Aquaculture and the Administration of Coastal Resources in British Columbia.* Public Report No. 15. December 1988, Victoria, BC.
[28] Personal communication with project interviewee, December 1997.
[29] Salmon Aquaculture Review, 1997. *Summary Report*.
[30] British Columbia *Environmental Assessment Act,* 1994. Section 40(1) a and b.

The government defined the terms of reference for the review after consulting with First Nations, environmental organizations and industry.[31] The terms of reference included five key issues: impacts of escaped farm salmon on wild stock, disease in wild and farmed fish, environmental impacts of waste discharged from farms, impacts of farms on coastal mammals and other species, and siting of salmon farms. The socioeconomic impacts of existing salmon farms in BC, the management and regulatory framework for salmon aquaculture and a comparison of the regulatory framework for salmon aquaculture in other jurisdictions were also to be examined.[32] The terms of reference given the Environmental Assessment Office required examination of the ecological concerns related to each of the five key issues at current levels of production. The Environmental Assessment Office was not asked to consider whether salmon aquaculture should continue in BC, but rather how it could be managed more effectively.[33]

A Technical Advisory Team was established with scientists from universities and consulting agencies assigned to review the five key issues, and legal and economic experts considering the socioeconomic effects of salmon aquaculture and its regulatory framework.[34] A Review Committee was also established, with representatives of First Nations, environmental organizations, industry, local governments, the United Fisheries and Allied Workers Union, and commercial and sports fishers.[35] The Technical Advisory Team researched and wrote reports on the five key issues and reported findings to the Review Committee, which commented on the papers. The Review Committee communicated the concerns of local communities, industry, and environmental organizations directly to the Technical Advisory Team. First Nations representatives gave input to the review through a separate process.[36]

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[31] Personal communication with project interviewee, December 1997.

[32] Salmon Aquaculture Review, 1997. *Summary Report*.

[33] Salmon Aquaculture Review, 1997. *Response to Public Comment on Proposed Review Process and Draft Terms of Reference, with Revised Review Process and Terms of Reference.* Environmental Assessment Office.

[34] Authors of each paper are as follows:

Key Issue A: *Escaped Farm Fish* – Dr. Dayton Lee Alverson, President of Natural Resources Consultants Inc., and Professor at the University of Washington.

Key Issue B: *Fish Health* – Dr. Craig Stephen, Director of Centre for Coastal Health and Assistant Professor at the Department of Health Care and Epidemiology, University of British Columbia. Dr. George Iwama, Co-author.

Key Issue C: *Waste Discharges* – Dr. Brenda Burd, President of Ecostat Research Ltd. and Research Associate at the Oceanography Department, University of British Columbia. Dr. George Iwama, Co-author.

Key Issue D: Marine Mammals and Other Species - Dr. George Iwama, Professor, Department of Animal Science, University of British Columbia. Dr. Brenda Burd, Co-author. John Ford and Linda Nichol provided technical advice.

Key Issue E: *Fish Farm Siting* – Catherine Berris, President, Catherine Berris Associates Inc.

The Socioeconomic Impacts of Existing Salmon Farming Operations in British Columbia – Marvin Shaffer, President, Marvin Shaffer and Associates.

Management and Regulatory Framework for Salmon Aquaculture in British Columbia – Ann Hillyer, partner, Hillyer Atkins.

A Comparison of the Regulatory Framework for Salmon Aquaculture in Selected Jurisdictions – Ann Hillyer.

NB: Only the scientific papers were reviewed for this study.

[35] Salmon Aquaculture Review,, 1997. *Response to Public Comment on Proposed Review Process and Draft Terms of Reference, with Revised Review Process and Terms of Reference.*

[36] Personal communication with project interviewee, November 1997.

Open houses were held in local communities throughout Vancouver Island to hear local residents' concerns. The Broughton Archipelago was chosen as a special study area due to the large number of farms operating in the area, and a Broughton Archipelago Information Subcommittee was established to survey its residents.[37] Technical papers were placed on the Environmental Assessment Office's website for public review. Many written submissions from concerned citizens were received and the technical papers were reviewed by other scientists. From this information the Technical Advisory Team members prepared their final reports and made recommendations to the Environmental Assessment Office on improvements to the regulatory scheme.

In August 1997 the Environmental Assessment Office presented the two responsible ministries, the Ministry of Agriculture, Fisheries and Food and the Ministry of Environment, Lands and Parks, with an 1800 page final Salmon Aquaculture Review document, with 49 recommendations. The report concluded that

> ... salmon farming, as presently practiced and at current production levels, presents a low overall risk to the environment. However, this general finding is tempered by certain reservations. First, continuing concern about localized impacts on benthic (seabed) organisms, shellfish populations and marine mammals suggests the need for additional measures to protect them. Second, significant gaps in the scientific knowledge on which the Technical Advisory Team's conclusions are based point to the need for monitoring and research in areas such as the potential impacts of interactions of escaped farmed salmon with wild populations, identification and control of disease and disease pathogens, potential for disease transfer and impacts from antibiotic residues, and effects of waste discharges on water quality and seabed life.[38]

Concerning applications for new aquaculture operations, the review recommended establishment of fish farm review committees to make siting and management decisions in lieu of requiring individual assessments for each new farm proposal. Public participation in these salmon farm siting and management decisions would be ensured by establishing local working committees. As well, the report recommended that a fish health working committee be established to develop corporate fish health policy and that strategies be developed to address First Nations concerns about siting of farms. The recommendations incorporated the Technical Advisory Team's advocacy of more technical measures to strengthen disease surveillance and control programmes, implementation of a performance-based waste management model, enforceable predator control rules that would strictly control the killing of predators and ban acoustic deterrent devices, development of a strategy to prevent escapes of farmed salmon and/or reduce the ecological risks of escapes, and reduction of the risks associated with salmon farming through performance based programme implementation with comprehensive monitoring.[39]

The findings of the Salmon Aquaculture Review have not ended the debate surrounding salmon farming. In order to understand why the controversy continues it is important to review the process that took the Technical Advisory Team to these conclusions. Of particular importance is how the Team dealt with a set of crucial factors

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[37] Iwama, George *et al*. 1997. *Aquatic Mammals and Other Species.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part E.
[38] Salmon Aquaculture Review, 1997. *Summary Report*.
[39] Salmon Aquaculture Review, 1997. *Summary Report*.

in the assessment: the limitations of available data, associated uncertainties about the probability and significance of the environmental effects of salmon aquaculture, different criteria for determining what could be considered valid testimony or evidence of impacts, and what types of predictions and judgments could be made.

The Terms of Reference

In November 1995, the Environmental Assessment Office circulated the draft terms of reference and proposed review process to stakeholders for comment. The Ministers of Agriculture, Fisheries and Food and Environment, Lands and Parks directed the Environmental Assessment Office to

- provide recommendations under section 40 of the Environmental Assessment Act,
- provide assistance with policy development with respect to salmon farming, and
- ensure a socioeconomic context is developed for the Environmental Assessment Office recommendations.[40]

The key issues for review were escaped farm salmon, fish health, waste discharges, aquatic mammals and other species, the siting of salmon farms, socioeconomic impacts of salmon farming, the regulatory framework for salmon aquaculture and a comparison of BC's regulatory framework with those of other jurisdictions.[41] Members of the Technical Advisory Team interviewed for this report found the terms of reference to be useful and complete. They kept research focused, but were flexible enough to allow changes.[42]

Others, such as Review Committee member Howard Breen of the Georgia Strait Alliance, have argued that the review terms of reference constrained the assessment significantly. They note three main concerns. First, the Environmental Assessment Office was asked to determine how the aquaculture policy framework could be improved, not whether salmon aquaculture should continue to be permitted in BC.[43] Second, the Technical Advisory Team members were required to consider the impacts of aquaculture at current levels of production and were not asked to anticipate and evaluate the cumulative effects of an expanded industry. Third, the terms of reference did not include assessment of the impacts of salmon aquaculture on global sustainability.[44] These limitations of the terms of reference affected the ability of the Salmon Aquaculture Review to evaluate fully the impacts of salmon farming in BC.

How, not whether

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[40] Salmon Aquaculture Review, 1997. *Response to Public Comment on Proposed Review Process and Draft Terms of Reference, with Revised Review Process and Terms of Reference.*
[41] Salmon Aquaculture Review, 1997. *Summary Report*.
[42] Personal communication with project interviewee, December and November 1997.
[43] Salmon Aquaculture Review, 1997. *Response to Public Comment on Proposed Review Process and Draft Terms of Reference, with Revised Review Process and Terms of Reference.*
[44] Tyedmers, Peter, *et al.* 1996. *Comments Regarding Salmon Aquaculture Environmental Review: Terms of Reference and Technical Paper Outlines*. Submission to the Environmental Assessment Office for the Salmon Aquaculture Review. Project Registry no. 000419.

When the Salmon Aquaculture Review was first being proposed, some members of the Review Committee thought that they would be able to discuss whether salmon aquaculture belonged in BC at all.[45] This proved not to be the case. Salmon aquaculture was well established in BC by the mid-1990's, therefore the government wanted to be able to manage the industry in a manner that would solve existing problems, rather than consider its removal.[46] Thus assessment of the desirability of salmon aquaculture in BC was left outside Environmental Assessment Office's mandate. It is not publicly known what environmental considerations were a part of this political decision.

Cumulative effects

The BC *Environmental Assessment Act* requires that the cumulative impacts of a project be considered in assessment reviews.[47] Because the review was of the impacts of the entire industry, assessing some of the cumulative impacts of salmon farming was necessarily involved. However, by restricting the review to impacts at current levels of production, the assessment terms of reference effectively excluded consideration of the cumulative impacts of an expanded future industry.

Predicting the effects of a growing industry would have been problematic. It would have been difficult to describe impacts of growth without knowing how much growth could be expected and where it would be located. Neither of these could be projected easily until siting criteria had been set and the number of suitable sites on the coast established.[48] Nevertheless, the risks and likely severity of certain adverse effects inevitably become more serious as the industry expands. This is true, for example, of disease transfer problems. Many factors affect the risks of importing an exotic disease with shipments of salmon eggs from other parts of the world. The methods used for screening salmon eggs for disease operate with a 95 percent probability of detecting a prevalence level of above 5 percent.[49] However, because salmonid populations may have a 1 percent or 2 percent infection rate, the screening methods may be inadequate. Some diseases are vertically transmitted (from parent to egg), so are unaffected by surface disinfection techniques. Other control methods such as imposing a year long quarantine on imported eggs and allowing importation only from accredited facilities are meant to mitigate these inadequacies.[50] However, the system is not foolproof. This has prompted concern among scientists in the federal Department of Fisheries and Oceans (DFO) as well as among other marine stakeholders. An internal DFO letter from George Hunter to F.E.A. Wood and Dr. R. Beamish, obtained by David Ellis and Associates reads,

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[45] Personal communication with project interviewee, November 1997.
[46] Personal communication with project interviewee, December 1997, February 1999.
[47] British Columbia *Environmental Assessment Act,* 1994. Section 22(j).
[48] Personal communication with project interviewee, November 1997.
[49] Ellis, David and Associates, 1996. *Net Loss: The Salmon Netcage Industry in British Columbia.* Report for the David Suzuki Foundation.
[50] Ellis, David and Associates, 1996. *Net Loss: The Salmon Netcage Industry in British Columbia.* Report for the David Suzuki Foundation.

> It is our opinion that while the risk of exotic disease importation accompanying any single shipment of eggs from abroad is small, the cumulative risk from unlimited introductions in the future is large.[51]

Under current practices the number of imports may increase as industry grows. Accordingly, the cumulative risk of importing a disease will rise.

The same principle applies to the risk of escaped Atlantic salmon establishing a breeding population on the west coast. Continuing escapes into the marine environment repeatedly present chances that Atlantic salmon may establish, however small each individual chance may be. Gravid Atlantic females, juveniles and males with milt have been observed in BC streams and rivers.[52] In August and September 1998, 12 juvenile Atlantic salmon were captured in the Tsitsika river in BC, and through physiological tests it was determined that the fish were of wild origin. This event constituted the first confirmed breeding event of Atlantic salmon in Pacific waters.[53] Should the number of fish escapes increase as industry increases, then the chances of escapees establishing a breeding population will increase.

These cumulative risks were examined in different ways by each author. Dr. Alverson, author of the escaped Atlantic salmon discussion paper stated that while he could speculate on likely effects of expansion, he could not quantify the effects by scaling up current effects.[54] Dr. George Iwama, lead author of the marine mammals and other species discussion paper and co-author of the fish health paper, stated that he didn't speculate on the effects of an increased industry because it wasn't in the terms of reference and that though it was possible to make educated guesses, they would be hypothetical.[55] Dr. Brenda Burd, author of the waste discharges discussion paper, took a different approach, saying that she tried to make recommendations that were applicable at any level. The best recommendations would be those that protected the environment at any level of production.[56] Dr. Craig Stephen, lead author of the fish health discussion paper, said that the data were inadequate for reliable forecasts especially considering how difficult it had been to determine the effect of current production. Predictions had to remain general.[57]

Effects beyond BC

Besides the impacts that an industry may have on the local environment, certain practices may affect ecosystems around the world. The ecological footprint of salmon aquaculture extends far beyond the borders of BC. Ideally, environmental assessments should consider not just the local impacts of a certain practice but also its contribution to global environmental sustainability. Because feed for farmed salmon comes from other parts of the world, salmon aquaculture has a considerable global impact. However, the terms of

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[51] Ellis, David and Associates, 1996. *Net Loss: The Salmon Netcage Industry in British Columbia.* Report for the David Suzuki Foundation. p 190.
[52] Personal communication with project interviewee, October 1997.
[53] Department of Fisheries and Oceans. "Atlantic salmon in the Tsitsika River" Backgrounder, 23 December 1998.
[54] Personal communication with project interviewee, November 1997.
[55] Personal communication with project interviewee, November 1997.
[56] Personal communication with project interviewee, November 1997.
[57] Personal communication with project interviewee, December 1997.

reference for the Salmon Aquaculture Review did not permit consideration of salmon aquaculture impacts outside BC.

Farmed salmon require a great deal of high-quality protein in their feed in order to replicate wild diets.[58] Today's most advanced feeds contain 42 percent protein and 33 percent fat[59] and finding sources for this protein is difficult. In Canada it is illegal to use fish suitable for human consumption for fish meal. The aquaculture industry side-steps this law by importing fish meal from South America where anchoveta, sardine and jack mackerel fisheries supply fish meal producers.[60] Because of demand, Chilean and Peruvian fisheries have expanded production. These fisheries are vulnerable to the combined effects of the El Niño and overharvesting. In the early 1970's and 1980's, the anchoveta fishery collapsed, increasing pressure on the sardine and mackerel fisheries. There is concern that the current rate of exploitation of these fisheries is not sustainable.[61]

A useful method of characterizing the sustainability of a product is a cradle-to-grave analysis of the materials and methods used to produce the product and the wastes the product leaves behind. David Ellis and Associates have calculated that "fish taken from the Pacific Ocean off South America provided 118,000 tonnes of fish to produce 32,000 tonnes of farmed salmon which produced sewage equivalent to that generated by 500,000 people."[62] This represents a substantial net loss of protein in the production of farmed salmon.

Making salmon feed from South American fish which could be used for human consumption would seem to be a step away from global sustainability. Representatives of a number of environmental organizations wrote the Environmental Assessment Office to bring this issue to their attention. Their concern was that "the expansion of the BC salmon aquaculture industry has the potential to directly contribute to the global fisheries over-harvesting crisis."[63] They asked the Environmental Assessment Office to include a clear statement in the terms of reference requiring the assessment of "the sources and quantities of the material and energy inputs to, and outputs from, the salmon culture industry in BC."[64]

Part of the mandate of the BC *Environmental Assessment Act* is to "promote sustainability by protecting the environment while fostering a sound economy and social well-being,"[65] Nevertheless, the Environmental Assessment Office chose not to expand the terms of reference to include a "cradle to grave" accounting and the topic was not included in the final report.

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[58] Ellis, David and Associates, 1996. *Net Loss: The Salmon Netcage Industry in British Columbia.* Report for the David Suzuki Foundation.
[59] Ellis, David and Associates, 1996. *Net Loss*.
[60] Ellis, David and Associates, 1996. *Net Loss*.
[61] Ellis, David and Associates, 1996. *Net Loss*.
[62] Ellis, David and Associates, 1996. *Net Loss*.
[63] Tyedmers, Peter, *et al.* 1996. *Comments Regarding Salmon Aquaculture Environmental Review: Terms of Reference and Technical Paper Outlines.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review. Project Registry no. 000419
[64] Tyedmers, Peter, *et al.* 1996. *Comments Regarding Salmon Aquaculture Environmental Review.*
[65] British Columbia *Environmental Assessment Act,* 1994. Section 2(a).

Methodology for Ecological Studies

The scientific literature

The five Technical Advisory Team reports on key issues were literature reviews, evaluated by peers before publication. The Team members had insufficient time, money and authority to conduct new research. New research would take years to design, implement and complete and may have been premature without a thorough review of the literature to determine directions for study.[66] Primary literature – peer reviewed studies published in recognized journals – was lacking in all five issue areas, but there was more grey literature such as government studies and proceedings at symposia that provided basis of research.[67] Much of the literature available to the review consisted of studies based on observation rather than rigorous experimentation testing hypotheses.[68] Other primary literature included studies of ecosystems in other countries that are much different from those in BC; therefore applying those lessons to BC's situation was problematic. Finally there was a wealth of observations by local residents, fishers and First Nations that did not qualify as conventional scientific knowledge but was nonetheless potentially available for the review.

Much of the existing scientific literature is from other parts of the world that have experience in salmon aquaculture, especially Norway, Scotland and Ireland. There was considerable controversy over how to apply this information to BC. In the end it was not given as much weight as studies conducted in BC, but it had to be used to some extent because of the paucity of local studies. The Norwegian work was perhaps especially useful because of the extensive experience with salmon farming in Norway, documented cases of disease transfer from farmed to wild stocks, and information on escapes and establishment of farmed salmon.

BC is the only jurisdiction in the world that farms Atlantic salmon in ecosystems that include species of Pacific salmon, which have different behaviour patterns and habitat requirements than Atlantic salmon. For this reason, some critics believe studies from areas that do not have Pacific species of salmon have limited relevance to the BC situation.[69]

What is clear is that the interpretation of foreign studies for the Salmon Aquaculture Review presented some difficulties. These difficulties may have been aggravated by questionable use of material from foreign studies in the BC review reports. One example is the handling of the Norwegian studies on disease transfer in the fish health discussion paper. This paper was reviewed by three Norwegian scientists who have published papers on disease transfer between farmed and wild fish in Norway. They found that not all the relevant literature had been included, and some of the papers used were quoted selectively or misinterpreted.[70]

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[66] Personal communication with project interviewee, November 1997.
[67] Personal communication with project interviewee, November 1997.
[68] Personal communication with project interviewee, October 1997.
[69] Personal communication with project interviewee, October 1997.
[70] Fleming, Ian *et al. Review of Key Issue B: Fish Health by Craig Stephen and George Iwama for the British Columbia environmental assessment of salmon aquaculture.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review, project Registry no. 000700. It is important to note that these comments were based on an earlier draft of the Fish Health discussion paper. However, a careful

The lack of primary scientific literature specific to BC posed a difficult practical problem for the Technical Advisory Team: what type of knowledge would be acceptable for determining how salmon aquaculture interacts with the environment and for determining what risks are involved? To fill in gaps left by the primary literature Team members were forced to consider anecdotal evidence, traditional ecological knowledge and grey literature. Though the Technical Advisory Team members did discuss how to apply unconventional evidence,[71] there was little consistency in their actual approaches.

Traditional ecological knowledge

First Nations communities have borne the brunt of many impacts of salmon farming and have provided a great deal of information regarding impacts on local environments after the arrival of salmon farms. Their coastal communities are near numerous salmon farms, many of which were sited without proper consultation. Because First Nations' culture is inextricably linked to the land and sea resources, impacts on the health of the sea and its resources can be devastating to a community.[72] First Nations' cultures have built generations of experience into an extensive and often detailed understanding of the land they live on. In some respects this traditional ecological knowledge comprises a far more thorough understanding of BC's coast than conventional scientific knowledge now offers.

First Nations representatives were members of the Review Committee and participated in a separate process. First Nations representatives also submitted position papers and reports to the Environmental Assessment Office and took Technical Advisory Team members on tours of sites of their traditional territories that were near salmon farms. All members of the Technical Advisory Team recognized the importance of traditional ecological knowledge.[73] However, a common approach of Team members was to use information presented by First Nations representatives to provide direction for conventional scientific research.[74] In this way the Team used conventional scientific knowledge to corroborate what First Nations members had observed. However, these two types of knowledge are not easily compared because they come from two very different points of view.[75] No one is certain how exactly to interpret traditional knowledge when developing resource policy. In order to improve relations between First Nations and government as well as gain a better understanding of the environment of BC, this problem deserves more study.

Anecdotal evidence

Presentations made at open houses and letters from concerned citizens submitted to the Environmental Assessment Office provided some anecdotal evidence of environmental effects of aquaculture. Anecdotal evidence and traditional ecological knowledge were also

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reading of the final draft reveals that the concerns identified by Dr. Fleming *et al*. and by Dr. Thorburn in her review were not addressed in the final draft.

[71] Personal communication with project interviewee, February 1998.

[72] British Columbia Aboriginal Fisheries Commission, 1997. *Submission to the Environmental Assessment Office for the Salmon Aquaculture Review.*

[73] Personal communication with project interviewee, November 1997, December 1997.

[74] Personal communication with project interviewee, December 1997, November 1997.

[75] Personal communication with project interviewee, November 1997.

actively gathered by the Environmental Assessment Office for the purposes of the review. A Broughton Archipelago Information Subcommittee was established to survey observations made by residents of the Archipelago concerning the effects of fish farming. The Subcommittee, with four representatives from local government, two First Nations representatives, and one representative each from the Pacific Trollers Association, industry and the United Fisheries and Allied Workers Union (UFAWU), gathered information from local residents and organized open-houses, organized the observations in categories under the five key issues, and then passed the package to the Technical Advisory Team members for review.[76]

Again, the Technical Advisory Team members varied in their interpretations of this anecdotal evidence. The authors of the aquatic mammals discussion paper listed the public observations in an appendix and clearly stated how they were incorporated into the paper. Though not given as much weight as scientific primary literature, these observations were used to clarify impacts in BC and were described as "very valuable for this process."[77] Other authors considered the comments to be more political than substantive, so did not consider them as carefully.[78]

In the fish health discussion paper, the case of the disease transfers in the Broughton Archipelago was discussed. The authors wrote,

> it has been hypothesized for our case study that the enhanced population acquired their infections from Atlantic salmon in nearby farms. ...it is not possible to rule out some connection between farmed and wild fish in this case based on such data. It also does not allow us to conclude whether the pathogens moved from farmed to wild fish or vice versa. This case does illustrate how the coincidental finding of the same species of a pathogen in two different populations is insufficient evidence with which to determine that the pathogens have been exchanged between the two groups.[79]

The conclusion of the authors seems to be that because there is no documented case that would stand up to peer review this evidence for interaction cannot be accepted. Alexandra Morton, a whale researcher in the Broughton Archipelago, feels that the case was brushed off. She said that although it is difficult to know how to weight anecdotal evidence, at some point one must stop believing in coincidences and give anecdotal evidence some more weight.[80]

As investigations into the environmental impacts of salmon aquaculture continued, it became clear how little information was available. This created serious uncertainty in understanding impacts and then recommending measures to mitigate them. The increasingly accepted response in such a situation is to use the precautionary principle: where uncertainty regarding an action exists, it is best to prevent harm before it occurs. The following section will examine the use of this principle in the Salmon Aquaculture Review.

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[76] Iwama, George *et al*. 1997. *Aquatic Mammals and Other Species.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part E.
[77] Iwama, George *et al*. 1997. *Aquatic Mammals and Other Species.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part E.
[78] Personal communication with project interviewee, November 1997.
[79] Stephen, Craig, and George Iwama, 1997. *Fish Health.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part C.
[80] Personal communication with project interviewee, December 1997.

Standard of proof of ecological harm and the precautionary principle

The problem of uncertainty in the review raised the question of what standard of proof was appropriate – what would constitute adequate evidence that aquaculture caused or threatened significant environmental harm? Environmental decisions are often based on evaluations that consider the balance of probabilities,[81] whereby harm is recognized if the evidence suggests it is more likely than not. This is a softer test than the "proof beyond reasonable doubt" standard of criminal law. But even proof on the balance of probabilities is difficult when there is little directly relevant scientific study information, as in the BC salmon aquaculture case.

In such a situation a thorough understanding and application of the precautionary principle becomes very important. The precautionary principle simply states that where there is uncertainty about the potential effects of an action on the environment it is better to use caution and take action to prevent possible harm before it happens. This is essential because "often studies which do not find that an environmental effect is occurring may actually have a very low chance of detecting such an effect if it did exist. The bias towards underestimating environmental damage must be recognized in legislation and policy."[82]

The precautionary principle was recognized and applied in a general manner by the Salmon Aquaculture Review. The report states that

> since the [precautionary] principle has a range of interpretations, perhaps the best way to apply it is as a guiding principle. It should encourage, or perhaps even oblige, decision-makers to consider the potential for harmful effects of activities on the environment before they approve those activities ... While it is important to fully understand the impacts of escaped farmed salmon on wild salmon, it is probably more important to prevent their escape to avoid unknown impacts.[83]

The Technical Advisory Team's main application of the precautionary principle was in recommendations for a system of adaptive management to oversee an expanding salmon aquaculture industry.[84] More ambitious application of the principle was discouraged by the direction from the government, which did not allow for consideration of whether salmon aquaculture should be permitted to continue in BC. Technical Advisory Team members and participants on the Review Committee were not allowed to consider the option of phasing out salmon aquaculture if the risks seemed to be too great. It is not clear whether the reviewers' scope would have permitted consideration of reducing production levels or continuing the moratorium.

Individual authors varied in their interpretation of how to deal with uncertainty and how to apply the precautionary principle. The authors in each area had to determine what proof was needed to find that a significant adverse effect had occurred. Because of

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[81] Personal communication with project interviewee, September 1997.

[82] Hillyer, Ann et al. 1993. *Recommendations for the Proposed British Columbia Environmental Protection Act.* West Coast Environmental Law Association.

[83] Salmon Aquaculture Review, 1997. *Summary Report*. Managing Risk and Uncertainty. Environmental Assessment Office.

[84] Salmon Aquaculture Review, 1997. *Summary Report*. Managing Risk and Uncertainty.

differences in the issues and amount of information available in the issue areas, no one position on proof of harm could be applied in all studies. However, this led to inconsistency in the recommendations. The authors of the papers on waste discharges and marine mammals applied the precautionary principle more fully and made relatively cautious recommendations. This was perhaps partly due to the fact that there was more information on waste discharges and simpler solutions for reducing impacts on marine mammals and other species.[85]

In contrast, the paper on fish health received a great deal of criticism for weak interpretation of the precautionary principle. The paper set out the following main question: "is there a reasonable basis from which to conclude that the current practices and regulation of salmon farming in BC create new opportunities for exposure to disease risk factors or alterations in the susceptibility of non-farmed species in such a way as to create serious or irreversible damage to the health of non-farmed animals?"[86] This meant that those who believed disease transfer was occurring bore the burden of proving it, in the absence of good scientific information.

A more precautionary approach to the question would have shifted the burden to those who denied the problem: "Is there a reasonable basis from which to conclude that the current practices and regulation of salmon farming in BC do not create new opportunities to disease risk factors or alterations in the susceptibility of non-farmed species?"[87] Dr. Meg Thorburn, who reviewed the fish health discussion paper for the Salmon Aquaculture Review, noted that "it clearly rests the burden of 'proof' on the environmental, as opposed to the aquaculture, side of the question."[88]

Throughout the text, the authors of the fish health paper used the lack of firm evidence as a basis for discounting concerns about the adverse effects of salmon farming. The authors wrote that the

> occurrence [of infectious diseases] is documented in farmed fish more often than in wild salmon. This has led to the conclusion by some that the fish farming industry acts as an origin of infectious diseases in wild stocks...However, there is little evidence of significant adverse effects due to transmission of disease agents from farmed to wild fish.[89]

A draft of the fish health paper was sent to Ian Fleming at the Norwegian Institute for Nature Research (NINR). Fleming reviewed the paper in co-operation with the NINR's Rita Hatvigsen, who has published papers regarding the outbreak of *Gyrodactylus salaris*

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[85] The recommendations included in the paper on marine mammals and other species included phasing out acoustic deterrent devices over two years, and encouraging greater use of predator net systems to prevent habitual feeding on caged salmon (Salmon Aquaculture Review, vol. 3. Technical Advisory Team Discussion Papers, 1997). These recommendations are physically simple and inexpensive compared to recommendations for reducing the impacts of escaped farm salmon and reducing the probability of importing new diseases with Atlantic salmon eggs.

[86] Stephen, Craig, and George Iwama, 1997. *Fish Health.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part C.

[87] Thorburn, Meg. 1997. *A Review of Craig Stephen's Fish Disease Draft.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review. Project Registry document no. 000675.

[88] Thorburn, Meg, 1997. *A Review of Craig Stephen's Fish Disease Draft.*

[89] Stephen, Craig, and George Iwama, 1997. *Fish Health.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part C.

in Norway, and Andrea Grimnes at the Zoological Institute at the University of Bergen in Norway. They observed that

> in their reporting of the literature, [the authors] stress the weakness of evidence implicating the salmon farming industry, giving the impression that there is little or no effect...In several places, arguments appear to be developed in a fashion that deliberately supports a view that fish farming does not cause harm to wild salmonid populations.[90]

The fish health paper authors recommended steps to strengthen fish disease surveillance programmes and fish egg importation procedures to remove pathogens, but did not recommend the two courses of action that could have had the greatest assurance of reducing the risk of transferring diseases to wild stocks: banning the import of salmon eggs and requiring the use of closed containment systems rather than open netcages. These recommendations were not included in the final Salmon Aquaculture Review report.

The Recommendations of the Salmon Aquaculture Review

The final goal of the Salmon Aquaculture Review was to make recommendations to the government on improvements to the regulatory framework surrounding salmon aquaculture. Forty-nine final recommendations were presented to cabinet. Most of them focused on preventing and mitigating the adverse effects of aquaculture and dealing with uncertainty by using adaptive management. Major recommendations included the following:

- establish permanent Fish Farm Review Committees to ensure coordinated salmon farm siting and management decisions,
- develop integrated coastal zone management plans,
- assess existing salmon farms to determine if the farms are causing significant negative impacts that need to be corrected,
- advance the goal of eliminating escapes by focusing on escape prevention as the principal management strategy for eliminating and/or reducing the ecological risks of salmon farm escapes,
- strengthen disease surveillance and control programs,
- strengthen policies and programs respecting importation including only allowing the importation of surface disinfected eggs and establishing a maximum number of importations,
- strengthen control of drug use on salmon farms,
- develop a regulation under the *Waste Management Act* that implements a Performance Based Waste Management Model,

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[90] Fleming, Ian *et al.* 1997. *Review of Key Issue B: Fish Health by Craig Stephen and George Iwama for the British Columbia environmental assessment of aquaculture.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review. Project Registry document no. 000700.

- undertake focussed research projects that assess the impacts of salmon farming on shellfish and other wild fishery resources on a priority basis,
- implement enforceable predation prevention plans at all salmon farms,
- strictly control the killing of predators at farm sites,
- discontinue the use of acoustic deterrent devices,
- develop strategies to address First Nation concerns about siting of salmon farms,
- undertake coordinated scientific research, technological trials and inventory investigations based on the prioritisation of initiatives, and
- reduce risk through performance based program implementation supported by comprehensive monitoring.[91]

In the preparation of the five study reports, decisions on how to deal with the precautionary principle, uncertainty, the validity of foreign studies and the use of traditional knowledge were made more or less separately by Technical Advisory Team members. In contrast, the recommendations were reviewed and revised by all team members until they were satisfactory.[92] This was intended to ensure that the recommendations did not overlap and were consistent throughout. The Technical Advisory Team members considered the best methods to prevent and mitigate the adverse effects of aquaculture based on their findings. In April and May 1997, the Team's recommendations were presented to the Environmental Assessment Office, which considered them and submitted a final set of recommendations to cabinet in August 1997.[93]

Prior to submission to cabinet, the recommendations were revised by the Environmental Assessment Office secretariat directing the review, then revised again by the executive director of the Environmental Assessment Office. The goal in these revisions was to make the recommendations as consistent as possible and to ensure that they were economically and technically feasible.[94] The Environmental Assessment Office did not make many major changes to the general substance of the Technical Advisory Team recommendations, but some recommendations were significantly watered down. For example, the Technical Advisory Team's recommendation that production should be "moved to all-female or non-reproductive Atlantic salmon to prevent risks of colonization"[95] was changed to "conduct research, subject to consideration of other research priorities, into further domestication of farm salmon and development of all-female or non-reproductive Atlantic salmon."[96] in the final report. Also, the recommendation to "adopt the practice of genetic and physical marking of farmed Pacific salmon to enable the monitoring of genetic dilution among native Pacific salmon stocks"[97] was not included in the final set of recommendations.[98]

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[91] Salmon Aquaculture Review, 1997. *Summary Report*. Consolidated list of Recommendations.
[92] Personal communication with project interviewee, November 1997.
[93] Personal communication with project interviewee, December 1997. Salmon Aquaculture Review, 1997. *Summary Report*. p. 11.
[94] Gustavson, Kent. Personal communication, 4 December 1997.
[95] Salmon Aquaculture Review, 1997. *Technical Advisory Team Discussion Papers*. p A-20.
[96] Salmon Aquaculture Review, 1997. *Summary Report*. Consolidated List of Recommendations.
[97] Salmon Aquaculture Review, 1997. *Technical Advisory Team Discussion Papers*. p A-20.
[98] Salmon Aquaculture Review, 1997. *Summary Report*. Consolidated List of Recommendations.

Revisions for feasibility may have been necessary because only some of the authors had considered the feasibility of their recommendations during the original drafting.[99] However, the Environmental Assessment Office's revisions to ensure feasibility apparently did not involve an iterative process of careful consultation with the Technical Advisory Team authors.[100] Arguably, the broad expertise of the Technical Advisory Team would have been as valuable in deliberations on feasibility as in deliberations on mitigation measures necessary to reduce impacts to "acceptable" levels. Certainly feasibility and mitigation adequacy decisions are interdependent and there is some danger that feasibility revisions made without reference back to the technical experts may have led to a weakening or removal of recommendations that the team judged necessary to ensure adequate mitigation, and for which the technical team could have identified more feasible substitutes.

Despite the Environment Assessment Office's efforts, some observers have argued that its finalized recommendations are still not realistic. For example, some of the recommended means of ensuring adequate mitigation appear to rely heavily on effective implementation of stronger regulations. Critics of the government's record in enforcement of current regulations believe it is not realistic to expect effective enforcement of more onerous requirements.[101] There are also questions about the feasibility of recommendations for new regulations, tougher enforcement and new research that would entail significant new costs for government. The Environmental Assessment Office did not shy away from imposing costs on government,[102] but the ministries affected are expected to push for a final decision that is less expensive to implement.[103]

The tension between mitigation adequacy and political and economic feasibility is perhaps unavoidable in the framing of recommendations in such cases. The Environmental Assessment Office insists that political neutrality was an integral part of the process and was carefully observed in formulating the final recommendations.[104] But judgements about mitigation sufficient to allow only "acceptable" impacts, and judgements about the feasibility of recommendations, are necessarily value-laden and political in the broad sense. Political significance and sensitivity is even more obvious in trade-offs between mitigation adequacy and feasibility. Alexandra Morton has noted that two additional recommendations – banning of the culture of Atlantic salmon, and moving production into closed containment, land based systems – could have done great deal to eliminate risks of aquaculture. However, adoption of these recommendations was thought to raise feasibility problems, in particular that the government would be unwilling to pay for

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[99] Dr. George Iwama, lead author the marine mammals and other species paper, said that he did not consider the feasibility of his recommendations because it wasn't in the terms of reference (Iwama, George. Personal communication, 7 November 1997). Dr. Brenda Burd, the author of the discussion paper on waste discharges, said that the economic and practical feasibility of the recommendations were considered with the help of the Ann Hillyer, author of the discussion paper on the legal framework of salmon aquaculture, and Marvin Shaffer, author of the discussion paper on socio-economic impacts of salmon aquaculture (Burd, Brenda. Personal communication, 21 November 1997).

[100] One Team member mentioned that even months after the public release of the Salmon Aquaculture Review document, he still had not looked at the Environmental Assessment Office's recommendations in detail. Personal communication with project interviewee, November 1997.

[101] Personal communication with project interviewee, October 1997.

[102] Personal communication with project interviewee, December 1997.

[103] Personal communication with project interviewee, November 1997.

[104] Personal communication with project interviewee, November 1997.

implementation of these measures and that the industry might not be economically viable if required to implement them without assistance.[105]

More fundamentally, the Environmental Assessment Office is required to choose among the two competing objectives of BC *Environmental Assessment Act.* The Act aims "to promote sustainability by protecting the environment and fostering a sound economy and social well-being," and "to prevent or mitigate adverse effects of reviewable projects."[106] Sustainability and prevention/mitigation are different and not necessarily compatible goals. Prevention/mitigation aims avoid or minimize anticipated adverse effects. It can be expected to make approved undertakings less damaging to the environment and to slow environmental decline. Promoting sustainability, in contrast, requires positive improvements.

The Environmental Assessment Office chose the lower hurdle in the salmon aquaculture case. Its recommendations aim to mitigate adverse effects. Recommended actions such as requiring salmon farmers to submit escape prevention plans to hold escapes to within a threshold number[107] and strengthening policies respecting importation of salmon eggs[108] should lessen the risks of escaped farm fish establishing breeding populations or of importing an exotic disease with imported fish eggs, but are not designed to eliminate these risks.

The questionable accuracy of the assessment judgements and the uncertain adequacy of the proposed controls, even for mitigation purposes, are recognized in the Environmental Assessment Office's recommendations for adaptive environmental management in the aquaculture industry. The adaptive system would focus on identifying gaps in knowledge, sponsoring research programmes to fill in these gaps, and adjusting regulations to adapt to new situations.[109] The rationale was that where identified risks were low, industry should proceed with caution and use adaptive management.[110] In the salmon aquaculture case, however, confident assessment of risks as high or low was precluded by a weak information base. Moreover, adaptive management is largely reactive – it involves watching for signs of trouble and then responding to them. As an approach developed in response to the recognized limitations of impact prediction and the prevailing uncertainties surrounding human activities, adaptive management is certainly appropriate for application to salmon aquaculture. But it is not preventative and, if the recommendations are accepted and implemented effectively, it will at best ensure that the effects of mitigation failures are minimized.

A last point about the Environmental Assessment Office's final report and recommendations concerns the role of the Review Committee. Most of the discussion here has focused on the role of the Office and the Technical Advisory Team. In the BC *Environmental Assessment Act* a significant role appears to be anticipated for the Review Committees established for individual assessments. In the salmon aquaculture case, however, the Review Committee had a nominal role. Members did not produce any reports of their own and could only suggest improvements to Technical Advisory Team

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[105] Personal communication with project interviewee, December 1997.
[106] British Columbia *Environmental Assessment Act,* 1994. Section 2 (a) and (c).
[107] Salmon Aquaculture Review, 1997. *Summary Report*. Recommendation 14.
[108] Salmon Aquaculture Review, 1997. *Summary Report*. Recommendation 19.
[109] Salmon Aquaculture Review, 1997. *Summary Report*.
[110] Personal communication with project interviewee, December 1997.

members. They did not play a meaningful part in formulating recommendations. Members represented local communities, environmental organizations, and unions – all were representatives of stakeholders who had responded to perceived damage done to the environment by salmon farming. In the end, some Review Committee members felt that the majority view of the Review Committee was not represented by the final report.[111]

Analysis: the effectiveness of the BC *Environmental Assessment Act*, as applied in the Salmon Aquaculture Review, in addressing complex ecological concerns

The Salmon Aquaculture Review addressed an important and controversial issue that needed open public attention. Moreover, it took assessment from an individual project focus to a policy level that was appropriate to the issues involved. In the course of this, the review allowed some valued participative opportunities, sought consensus, and attempted to foster communication between the public, stakeholders and the Environmental Assessment Office.

The review also suffered from significant limitations. The terms of reference constrained review to current levels of production, focused on mitigation, compromised the goal of sustainability in favour of promoting the economy, and did not consider global impacts of aquaculture. Most importantly, the review was hampered by the lack of primary literature relating to aquaculture in BC. This meant reliance on qualitative risk assessments, made uncertainty a major factor, and increased the importance of the precautionary principle, which the review recognized and applied inconsistently.

In a broader context, R.D. Jakimchuk has written that "the lack of technical information necessary to properly assess and adjudicate environmental conflicts is somewhat surprising considering the vast institutional apparatus for dealing with environmental matters in this country."[112] In the salmon aquaculture cases, the absence of suitable baseline data regarding interactions between salmon netcages and the environment in BC forced the Technical Advisory Team members to make individual judgments regarding what data and evidence were suitable to fill in the gaps. Because similar problems seem likely to plague future assessments, there are evident grounds for efforts to enhance the base of environmental research and to strengthen means of addressing uncertainties in assessments and associated decision making.

While Canada has considerable environmental research expertise, such research has lost place as a public funding priority and is increasingly pressed to serve economic objectives. There is very little support in BC for researchers who study environmental impacts of aquaculture.[113] The researchers who are employed on related matters in BC mostly work for industry or for the Department of Fisheries and Oceans.[114] Industry researchers are understandably obliged to focus on commercial needs and DFO, which has

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[111] Personal communication with project interviewee, November 1997.

[112] Jakimchuk, R.D. 1990? "The Role of Environmental Assessment in support of Sustainable Development" In: *Sustainable Development and Environmental Assessment.* Jacobs, P. and Sadler, B. eds. Canadian Environmental Assessment Research Council.

[113] Personal communication with project interviewee, October 1997.

[114] Personal communication with project interviewee, December 1997.

adopted a strong proponent's role for the salmon aquaculture industry,[115] is now also an unlikely sponsor of research that might uncover negative effects. The provincial Ministry of Environment, Lands and Parks is strapped for resources and after directing policy development and enforcing current regulations has little money left over for research. One attractive option would be to give the Environmental Assessment Office a mandate to anticipate future assessment needs and sponsor timely research aimed at collecting baseline data to facilitate assessment of the impacts of major industries. Environmental concerns regarding salmon aquaculture were voiced as early as the mid-eighties. The failure of government agencies to initiate some independent environmental research in the following decade was regrettable and could be avoided for future cases.

The salmon aquaculture case also reveals that the precautionary principle is still not well understood or appropriately implemented in current public policy decision making. The precautionary principle is meant to respect uncertainties and avoid risks of environmental damage to the environment. The prejudgement – made in the restrictive terms of reference – that salmon aquaculture should continue, despite the allegations of environmental damage caused by the industry and before the findings of the assessment, violated the principle. So did the judgements within the review that treated the absence of proof of damage as grounds for assuming the absence of negative effects, despite the evident weakness of available information. The precautionary principle, recognizing uncertainty, favours avoidance of potentially serious but ill-defined risks and implies that the burden of proof should fall on those who claim an activity is harmless, not on those concerned that it may be damaging. Ensuring better respect for the precautionary principle requires greater awareness among public officials. It may also require explicit attention in adjustments to the BC *Environmental Assessment Act* and its implementation guidelines concerning the weighing of evidence in conditions of risk and uncertainty.

Finally, the limitations of the salmon aquaculture review suggest that the *Environmental Assessment Act* would benefit from amendments that establish progress to long term sustainability, rather than mere prevention and mitigation, as the central decision criterion for all assessments. This would entail clarification of the Act's current commitment to sustainability, including recognition that economic and social well-being need to be pursued within ecological constraints and that the current deterioration of ecological capacities must be reversed. Until such a definition is set in the *Environmental Assessment Act,* the Environmental Assessment Office needs to realize that the goals of sustainability and economic well-being will conflict and that in some cases, economic interests may have to satisfied in other ways than those demanded by proponents.

In important ways the Salmon Aquaculture Review represents a step forward for environmental assessment in BC. It was a groundbreaking use of an environmental assessment to review a whole regulatory regime; it involved extensive consultation with the public; and it attempted to address a contentious issue in a public manner. It is not, however, a model for the pursuit of sustainability or for enlightened attention to complex ecological concerns.

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[115] Morton, Alexandra. 1996. Letter to Louis Tousignant, Director-General of the Pacific Region, Department of Fisheries and Oceans. Project Registry no. 000352. Georgia Strait Alliance, 1997. *Err on the Wild Side: the Case Against Netcage Expansion.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review. Breen, Howard. Personal communication, 20 November 1997.

References

Alverson, Dayton Lee, 1997. *Escaped Farm Salmon: Environmental and Ecological Concerns.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part B.

Beanlands, Gordon and Peter Duinker, 1983. *An Ecological Framework for Environmental Impact Assessment in Canada.* Institute for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia.

British Columbia Aboriginal Fisheries Commission, 1997. *BCAFC Salmon Aquaculture Review Submission, January 17th 1997.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review.

British Columbia *Environmental Assessment Act,* 1994.

Burd, Brenda, 1997. *Waste Discharges.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part D.

David Suzuki Foundation, 1996. "Salmon Farming Industry Threatens BC's Wild Fish Stocks" News Release, October 24, 1996.

Department of Fisheries and Oceans. "Atlantic Salmon in the Tsitsika River" Backgrounder. 23 December, 1998.

Ellis, David and Associates, 1996. *Net Loss: The Salmon Netcage Industry in British Columbia.* Report for the David Suzuki Foundation.

Fleming, Ian, Rita Hartvigsen and Andrea Grimnes, 1997. *Review of Key Issue B: Fish Health by Craig Stephen and George Iwama for the British Columbia environmental assessment of salmon aquaculture.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review, Project Registry Number 000700.

Georgia Strait Alliance, 1997. *Err on the Wild Side: The Case Against Netcage Expansion.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review

Gillespie, David. 1986. *An Inquiry into Finfish Aquaculture in British Columbia: Report and Recommendations.* B.C. Finfish Aquaculture Inquiry. 12 December, 1986.

Hillyer, Ann, Linda Nowlan, Christopher Rolfe, and Murray Mollard, 1993. *Recommendations for the Proposed BC Environmental Protection Act.* West Coast Environmental Law Association.

Iwama, George, Linda Nichol and John Ford, 1997. *Aquatic Mammals and Other Species.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part E.

Jakimchuk, R.D., 1990? "The Role of Environmental Assessment in Support of Sustainable Development." In: *Sustainable Development and Environmental Assessment: Perspectives of Planning for a Common Future,* ed. Barry Sadler and Peter Jacobs. Canadian Environmental Assessment Research Council.

Morton, Alexandra, 1997. *Introduction of Diseased Atlantic Smolts into the Broughton Archipelago: A Tale of Two Epidemics.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review, Project Registry Number 000522.

Morton, Alexandra, 1996. *Letter to Louis Tousignant, Director-General of the Pacific Region, Department of Fisheries and Oceans.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review, Project Registry Number 000352.

Owen, Stephen. Office of the Ombudsman. *Aquaculture and the Administration of Coastal Resources in British Columbia.* Public Report No. 15. December 1988.

Salmon Aquaculture Review, 1997. *Response to Public Comment on Proposed Review Process and Draft Terms of Reference, with Revised Review Process and Terms of Reference.* Environmental Assessment Office.
http://www.eao.gov.bc.ca/project/aquacult/salmon/t_of_ref.htm

Salmon Aquaculture Review, 1997. *Salmon Aquaculture Review vol. 1, Summary Report.* Environmental Assessment Office.
http://www.eao.gov.bc.ca/project/aquacult/salmon/report/toc.htm

Salmon Aquaculture Review, 1997. *Salmon Aquaculture Review vol. 2, First Nations Perspectives.* Environmental Assessment Office.

Salmon Aquaculture Review, 1997. *Salmon Aquaculture Review vol. 3, Technical Advisory Team Discussion Papers.* Environmental Assessment Office.

Stephen, Craig, and George Iwama, 1997. *Fish Health.* Salmon Aquaculture Review, vol. 3. Technical Discussion Papers, part C.

Thorburn, Meg, 1997. *A review of Craig Stephen's fish disease draft.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review, Project Registry Number 000675.

Tyedmers, Peter, Karen Wristen, Catherine Stewart and Laurie MacBride, 1996. *Comments Regarding Salmon Aquaculture Environmental Review: Terms of Reference and Technical Paper Outlines.* Submission to the Environmental Assessment Office for the Salmon Aquaculture Review, Project Registry Number 000419.

Case Report Interviewees

Alverson, Dayton Lee. Technical Advisory Team Member, Natural Resources Consultants, Inc. Personal communication, 5 November, 1997.

Barlow, Chris. Coordinator, Salmon Aquaculture Review, Environmental Assessment Office. Personal communication, 27 November, 1997, and 2 December, 1997.

Breen, Howard. Member of the Review Committee, habitat campaigner, Georgia Strait Alliance. Personal communication, 20 November 1997.

Burd, Brenda. Technical Advisory Team Member, President, Ecostat Research, Ltd. Research Associate, Institute of Ocean Sciences. Personal communication, 21 November 1997.

Coon, Mike. Acting Director, Aquaculture and Commercial Fisheries Branch, Ministry of Agriculture, Fisheries and Foods. Personal communication, 9 December, 1997.

Cooper, Rob. Environmental Law Centre, University of Victoria Faculty of Law. Lead author of "Critical Analysis of the Salmon Aquaculture Review: an Interim Report." Personal communication, 30 September 1997.

Cox, Bob. Member of Minister's working group for the Salmon Aquaculture Review, Ministry of Environment, Lands and Parks. Personal communication, 18 November 1997.

Gustavson, Kent. Coordinator, Salmon Aquaculture Review. Gustavson Ecological Resource Consultants. Personal communication, 4 December 1997.

Hunter, Lynn. Consultant, contracted to David Suzuki Foundation. Personal communication, 20 November, 1997.

Iwama, George. Technical Advisory Team Member, Professor, Department of Animal Science, UBC. Personal communication, 7 November, 1997.

Morton, Alexandra. Whale researcher, Raincoast Research. Personal communication, 2 December 1997.

Stancil, Daphne. Director, Salmon Aquaculture Review, Environmental Assessment Office. Personal communication, 27 November, 1997, and 12 February 1998.

Stephen, Craig. Member of Technical Advisory Team, Director, Centre for Coastal Health, UBC. Personal communication, 2 December, 1997.

Volpe, John. Researcher, graduate student at University of Victoria. Personal communication, 28 October, 1997.