SPEAKING FOR THE SALMON

SUMMIT OF SCIENTISTS ON AQUACULTURE AND THE PROTECTION OF WILD SALMON

JANUARY 25-27, 2007
INNER COAST NATURAL RESOURCE CENTRE and
LAWRENCE AMBERS RECREATION CENTRE
ALERT BAY, BC

CONVENER'S REPORT

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Speaking for the Salmon

www.sfu.ca/cstudies/science/salmon.htm

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in cooperation with

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Preface

Background

Currently, there are significant concerns in the scientific and general community with respect to government plans for the expansion of salmon aquaculture on the coast of British Columbia and the associated risks to wild salmon.

In particular, there is much focus on the Broughton Archipelago and sea lice infestations of out-migrating wild juvenile pink salmon, and on recent declines in adult pink salmon returns. These may be associated with the ongoing extensive development of the farming of Atlantic salmon in this region. A debate continues between and among academic and government scientists, but there is general agreement that the weight of evidence points to significant impacts of salmon farms on wild salmon populations.

Two recent Speaking for the Salmon workshops addressed the issue of sea lice and salmon in the Broughton Archipelago. A Community Workshop to Review Preliminary Results of 2003 Studies on Sea Lice and Salmon in the Broughton Archipelago Area was held in Alert Bay in January 2004. Recommendations for future research topics included:

- studies of the life cycles of sea lice in salmon farms and the natural environment;
- studies of the ecological interactions involving salmon farms, sea lice and juvenile salmonids; and
- establishment of key indicator stocks of Pacific salmonids to be used in annual escapement surveys.

In November 2004 the Scientists' Roundtable on Sea Lice and Salmon in the Broughton Archipelago area of British Columbia produced a statement of agreement with respect to the weight of evidence approach as a reflection of their understanding of the impact and significance of sea lice for wild salmon in BC. The following are excerpts from that statement:

- "in the absence of conclusive information about the impacts of sea lice on the pink salmon runs in the Broughton Archipelago the Precautionary Approach should be invoked in some form given the weight of evidence that exists;"
- and "we can take heed of the European experience that indicates that regulations can substantially reduce the impacts of sea lice on wild salmon."

Both of these reports can be viewed at www.sfu.ca/cstudies/science/salmon.htm

In the period since these two meetings new papers have been published in peer-reviewed journals, and the weight of evidence suggests a negative impact of salmon farms on pink salmon in the Broughton Archipelago. In addition, two relevant policy initiatives have been put in place: the Wild Salmon Policy released by DFO in June 2005 commits Canada to the protection and restoration of wild salmon biodiversity and; an MOU signed between a member of the aquaculture industry in the Broughton and a coalition of NGOs and First Nations (the Coastal Alliance for Aquaculture Reform, CAAR), commits these parties to collaborative research and monitoring of sea lice.

Purpose of the Summit of Scientists on Aquaculture and the Protection of Wild Salmon

It was important that this workshop deal only with the science underlying current and future policy and decisions, separate from political and societal considerations. This does not mean that the latter are not important - but for the purposes of this workshop the focus was entirely on the known science related to the understanding of interactions between wild and farmed salmon. To address the concerns of both the local and international communities with respect to the impacts of aquaculture in the Broughton Archipelago, a special community public evening session was held. This provided a rare opportunity for the local community to exchange knowledge with a group of international scientists and collectively seek solutions to reduce the impacts of salmon farms on wild salmon.

The summit of scientists represented a think tank of natural science experts in salmon from Europe, Atlantic Canada and British Columbia. Over three days they engaged in dialogue about salmon farming and the protection of wild salmon on the BC coast and considered recent research conducted around the Broughton Archipelago and elsewhere. During their discussions, this team identified impact pathways, management tools, and research gaps and priorities for future research projects and potential collaborations, and assessed the risks for wild salmon in BC perceived to be associated with salmon farming industry. At the end of the workshop they produced a Statement of Agreement with regard to their risk assessment.

Workshop Agenda
The three day dialogue evolved as follows:

Day 1
Field trip to the Broughton Archipelago, followed by three presentations on the interactions of farmed and wild salmon ranging from global to regional and local scales.

Day 2
Plenary discussion focused on:
- Impact pathways of farms for wild salmon including: disease and parasitism interactions, genetic interactions and ecological interactions
- Management tools including disease/parasite controls, coastal zoning, stock identification and others
- Information gaps and research directions, and
- Risk assessment.

Evening public meeting

Day 3
Break out groups discussions focused on three broad topics: Management tools (pros and cons of diverse tools); Research/knowledge gaps; and Risk assessment.

Plenary dialogue leading to the formation of the workshop Statement of Agreement.

The Convener's Report
The convener's report for the workshop presents the Statement of Agreement and summarizes the three days of dialogue that led up to the formation of this statement.

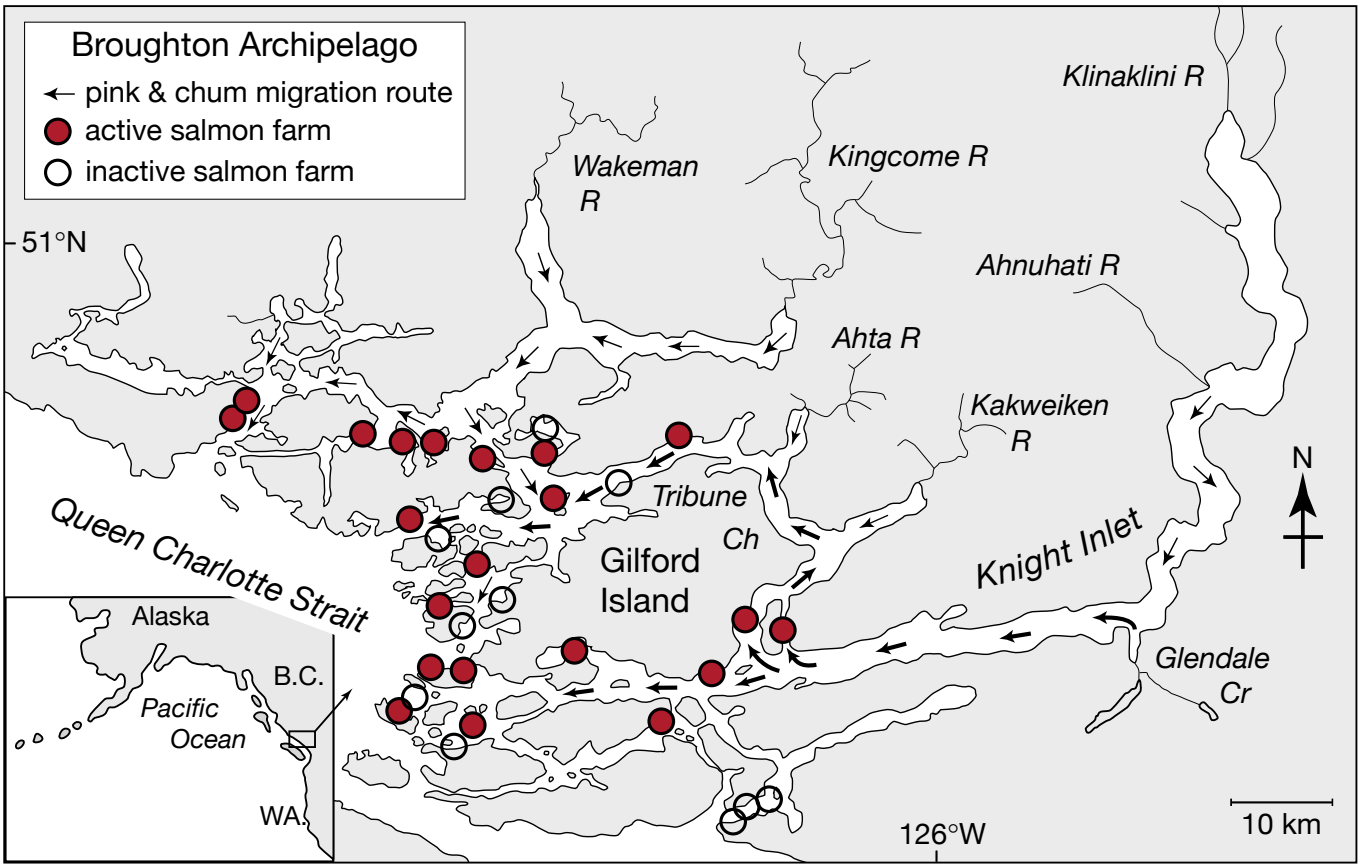

Figure 1. Canada's Broughton Archipelago is an important rearing area for juvenile pink and chum salmon. Map by N. Frazer, A. Morton and W. Soltau.

Statement of Agreement

European governments (Ireland, Scotland, Iceland, and Norway and the European Union) have recognized that salmon farming can be hazardous to the environment, including the proliferation of sea lice on salmon farms, posing significant risk to wild salmonids. There was general agreement at the meeting on the following:

- that the situation on the British Columbia coast has many parallels, but that the risks to pink and chum salmon are exacerbated by their small size at emergence into the marine environment,
- that these fish also play a vital role in coastal ecosystems, in particular as a source of marine-derived nutrients for riparian zones and as food for other species including adult chinook and coho salmon, orcas, bears, wolves and eagles, and
- that, both directly and through these impacts, pink and chum salmon play a key role in the economy and culture of local communities, with special significance to aboriginal peoples.

In light of these concerns, all parties should act expeditiously to develop cooperative solutions building upon the experience already gained in Europe and British Columbia.

Presentation Abstracts

Impact of Salmon Farming on Wild Salmon Survival: Results of an International Population Dynamics Meta-analysis

Jennifer Ford (presenter) and Ransom Myers, Dalhousie University, Halifax, Canada

Large declines of wild salmon populations in the North Atlantic and Pacific Oceans have been a source of serious concern. Although there are clearly many reasons for these changes, the hypothesis that salmon aquaculture is a major contributor to the widespread decrease in salmon survival has been suggested, but not demonstrated. To extract the effect of aquaculture, we paired each area with salmon farms to a nearby area without, so that common changes in survival could be removed. In a meta-analysis, we show that there is an association between increased farmed salmon production and increased mortality of five species of anadromous salmonids from seven regions of the North Atlantic and Pacific. The mean is a statistically significant reduction in survival of about 1% per generation per tonne of farmed salmon, in each area with salmon farms. This constitutes good evidence that salmon farming reduced survival of wild populations in the areas we investigated, over the last 15-30 years.

Towards sustainable salmon farming: Zoning of the Icelandic coastline

Sigurdur Gudjonsson, Institute of Freshwater Fisheries, Iceland

More than one hundred Icelandic rivers contain natural populations of Atlantic salmon, *Salmo salar L.*, that have high biodiversity value and support a sport fishery with an annual turnover of approximately Euro 130 million.

Companies experimented with cage rearing of salmon in Iceland in the 1980s and 1990s but these trials failed due to harsh environmental conditions. However, salmon have been farmed in land-based units since the 1980s. Proponents of salmon farming in Iceland claim that marine cage rearing can be successful as a result of the development of improved cage designs, better performing strains of salmon and other advances in husbandry. They argue that salmon farming creates jobs and improves the economy in rural areas but river owners and environmentalists fear that escaped farmed salmon will threaten the valuable wild stocks through genetic introgression and loss of local adaptations in these stocks and through transmission of parasites and diseases.

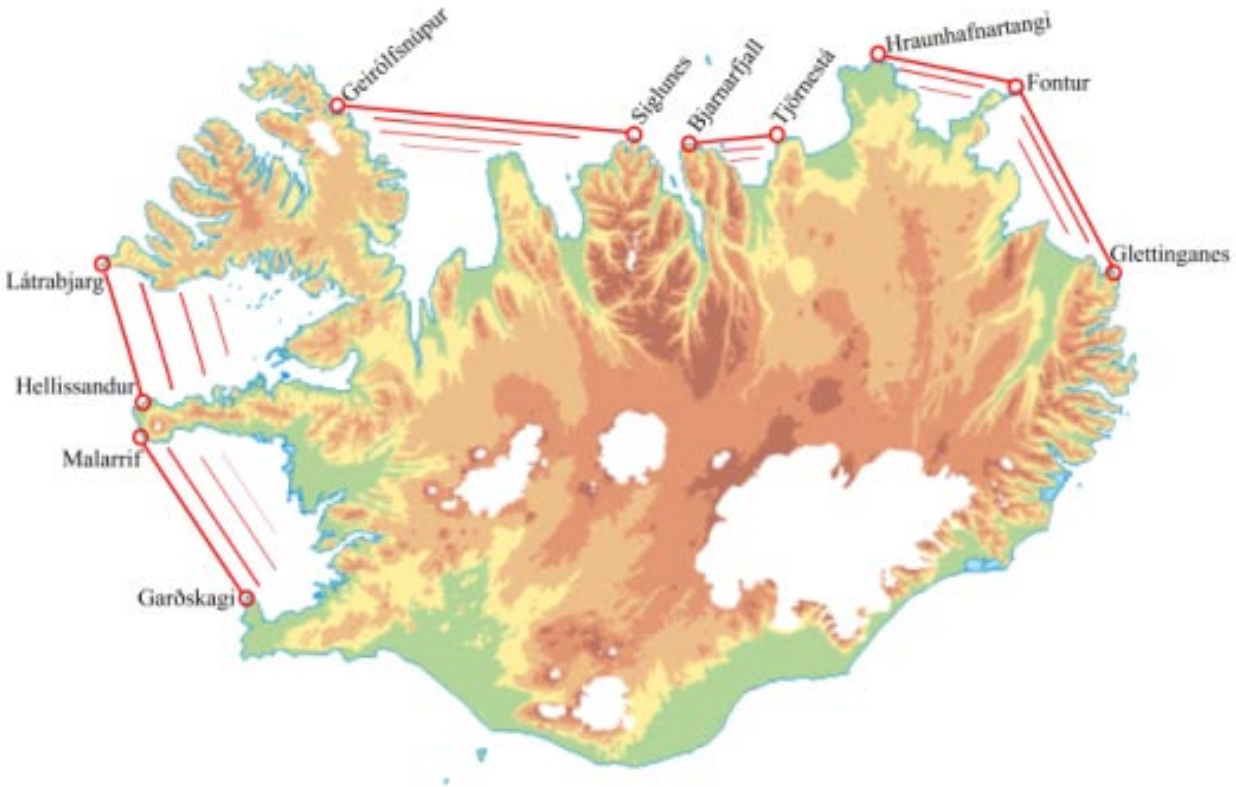

Figure 2. Areas of Iceland where salmon farming has been banned.

In response to these concerns, and after evaluating the experience of managing salmon farming and its interactions with wild salmon stocks in other countries, new legislation was ratified in Iceland in 2001 which entered into force in 2006 to allow the government to better manage the salmon farming industry.

Under this new legislation salmon farming is not permitted in the bays and fjords into which the most valuable salmon rivers drain (Figure 2). This was considered to be a step towards sustainable salmon farming and a compromise between the opposing views. Salmon farming is allowed only in designated areas and the experience gained from these areas will be evaluated in order to plan the future development of salmon farming in Iceland.

The Trouble with Salmon Farming - the Broughton Experience
Alexandra Morton, Raincoast Research, Simoom Sound, Canada

Salmon farms may have a place in BC, but it is important to note that the BC coast is a vibrant ecosystem producing wild salmon that are essential to the economy, culture and sustainability of the province. In 1990 the Norwegian Parliamentary Committee on the Environment warned that fish farmers came to BC to escape restrictive Norwegian measures (Hansard 12-9-1990). Pink salmon returns to the Broughton Archipelago declined with the onset of fish farming amid repeated farm epidemics of the bacterial disease, furunculosis. In a breach of public trust, the Province sited fish farms in the "red zones" they had pledged to keep farm-free at the request of community. The extreme diminutive size of pink and chum salmon and the placement of large, multiple salmon farms on their migratory corridors ensured sea louse epidemics in both farmed and wild salmon and significant impact. Salmon farms such as the Burdwood Island farm, placed immediately seaward of salmon rivers, ensure impact of farm pathogens on the most delicate, juvenile phase of the wild salmon. Non-government BC scientists have found up to 95% of juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon succumb to farm-origin sea lice in narrow waterways like Tribune Channel. In addition to parasites and bacteria, the virus IHN was reportedly spread by farm salmon smolt transporters up the coast where the infection spread rapidly among farms. Disease amplification is a serious concern because quarantine of infected populations in netpens is not possible. Herring are also highly susceptible to IHN. The potential to spread farm-origin pathogens is illustrated by the widespread origins of tagged chinook caught in the Broughton. Over one-third of all BC wild salmon are repeatedly exposed to salmon farms along the entire length of Vancouver Island. Hutchings et al. (1997) listed five steps by DFO that resulted in the collapse of the eastern cod. Each of these appears to be in play in BC in regards to salmon farming. The weight of evidence is undeniable, and farmed and wild salmon will be separated, either through decimation of wild stocks, or careful re-siting of salmon farms; it is only a question of whether we step in and control the outcome.

Summary of Plenary Dialogue

Impact pathways of salmon farms

Disease and parasite interactions with wild salmon

Disease interactions
The international participants in the meeting shared numerous insights on disease issues of importance in EU countries. Norway has legislation on how diseases and sea lice are reported and treated. Diseases such as infectious salmon anemia (ISA) are controlled by the slaughtering of farmed salmon on-site, mainly to prevent disease transmission between farms (with little focus on farmed-to-wild pathways), although the efficacy of these treatments is unclear. Every farm in Norway also has a registered veterinarian who reports to local regulators. Participants also noted there are approximately 14 strains of ISA in Atlantic Canada; that epidemics have occurred every year since 1996; that management options are limited; and that farmers can lose up to 30% of their annual production to this disease. ISA is not currently found in Scotland or BC.

Hutchings, J.A., Walters, C., and Haedrich, R.L. 1997. Is scientific inquiry incompatible with government information control? Can. J. Fish. Aquat. Sci. 54: 1198-1210.

Furunculosis was introduced to Norway for the second time (from Scotland) in 1985 (the first being 1964), and escaped smolts spread the disease to wild stocks. Furunculosis is cyclic and has disappeared but is expected to return. *Gyrodactylus salaris* is also an issue in Norway. *G. salaris* was imported to Norway with fish from Swedish hatcheries in the early 1970s. Atlantic salmon in the Baltic are immune to this parasite, Atlantic salmon parr in rivers on the Atlantic coast are vulnerable. Infected populations are almost eradicated (abundances decreased to approximately 10% of their former levels) a few years after the parasite is introduced. *G. salaris* has now spread to 45 Norwegian rivers where the salmon parr have been infected. Control is achieved through the eradication of hosts in small but not large rivers. *Gyrodactylus* is not found in Ireland or the United Kingdom and participants discussed how measures have been taken to prevent this parasite from reaching these areas.

In Scotland and Ireland, infectious pancreatic necrosis (IPN) and pancreas disease (PD) are the main disease issues. PD has a 40 to 50% mortality rate in Ireland, and has been Ireland's largest problem over the past 4 or 5 years. It is difficult to treat and has almost wiped out some farms, but does not seem to have any associated impact on wild stocks. Kidney disease may be a problem especially at temperatures higher than 15°C in hatcheries in Norway, where this disease has killed many wild salmon (spread from hatcheries).

In Canada, infectious haematopoietic necrosis (IHN) and infectious salmon anemia (ISA) are diseases of concern on the West and East coasts, respectively. IHN has been common on Broughton Archipelago salmon farms, and concerns were raised about the possibility that transporting live fish potentially spreads IHN. A participant also noted the difficulty of disease research especially for the non-profit sector seeking laboratory support. Finally in BC, *Kudoa thyrsites*, a parasite that effects the flesh of dead farmed fish, is also a concern for industry.

Sea lice parasitism

Sea lice are generally regarded as a greater concern than disease in EU countries and in Canada. Disease may exacerbate fish health and sea lice problems (especially if fish are not feeding and thus cannot be medicated against lice). Sea lice have been an 'ongoing story' since at least 1990 in Norway. Farmers were taught to count lice and about infection implications. A formal 'National Action Plan Against Sea Lice on Salmonids' came into effect in 1997, specifically to protect juvenile wild Atlantic Ocean salmonids. It mandates that lice be kept below 0.5 gravid females per farmed fish host in spring. Participants discussed how EU countries were generally ahead of Canada in terms of reporting on and controlling lice; how Pacific salmon (*Oncorhynchus spp.*) are substantially smaller and thus more vulnerable to louse parasitism than EU Atlantic (*Salmo spp.*) salmonids; and how 'trigger levels' for lice treatment might thus differ between Canada and the EU. Sea lice were also identified as a possible vector for diseases such as ISA (which has been found on lice).

The specificity of *Lepeophtheirus salmonis* on salmonids was discussed in light of recent observations of lice on marine sticklebacks in the Broughton Archipelago; the fact that no gravid lice had yet been found on sticklebacks was noted.

Participants also compared EU and Canadian lice reporting requirements, and noted that Marine Harvest Canada is the only industry member in Canada to have publicly shared data on fish and lice numbers. A suggestion was made that we need international standards on lice monitoring and reporting.

In regards to the question: Are sea lice the biggest concern? it was noted that lice parasitism may be easier to study than disease because lice are visible and researchers do not require a disease laboratory. There was also a general discussion on information sharing, the value of a summary of the history of pathogen problems on farms, and the time that it takes from when a disease becomes commercially important, to when an effective treatment becomes available, which Norwegian participants estimated to be around 6 years.

Genetics (international/regional) interactions

The discussion on potential genetic interactions began with a focus on Atlantic Canada, where the salmon farming (only in New Brunswick) industry is especially concentrated. There, escaped farmed salmon have outnumbered wild spawning salmon in rivers (by 10:1). These fish originally came from one river, the St. John River in New Brunswick, and had been subjected to at least 4 generations of domestic selection, so obviously were not 'native' in the streams.

The number of escapees has dropped and 2006 was the first year since 1994 in which wild fish outnumbered escaped farmed fish in Atlantic Canada rivers. It was noted that freshwater hatcheries are losing juvenile fish into systems, although this could be "fixed."

Internationally, escaped salmon also cause genetic impacts in rivers. Norwegian researchers have produced several reports, and twelve rivers will be studied over the next ten years in a program to determine genetic impact. The EU participants stressed that genetic impacts were as important (or more so) than lice and were also a prime driver behind recent decisions to zone parts of Norway 'farm free'. The major concern is the homogenization of wild stocks (due to continuous escapement from farmed fish), which in turn affects adaptations to local river conditions and reduces fitness. Genetic impacts are also a concern in Iceland, which has banned salmon farming from much of the coast to protect wild salmonids and Iceland's profitable sport fishery (see Sigurdur Gudjonsson abstract above).

Impacts of escaped fish in Ireland were thought to be less severe, where wild salmon stocks (as opposed to sea trout) are reasonably healthy. In Norway, farmed salmon now outnumber wild fish by 100:1, and it is estimated that in Norway there are fewer than 1 million wild Atlantic salmon remaining. Recently, some 300,000 additional salmon escaped from Norwegian farms. Crude estimates suggest there is 2-3% per year gene flow from hatchery to wild stocks. It was also pointed out that Canada has similar concerns about the genetics of wild fish associated with the release of nearly a half billion hatchery salmon each year into Pacific Ocean waters, but genetic issues with escaped Atlantic salmon are not an issue as there are no wild Atlantics (only Pacific salmon).

Ecological interactions

A Canadian scientist who has worked in Norway noted that ecological interactions lead to genetic ones, because there has to be interbreeding between the two forms of the species (*Salmo salar*). Interactions on breeding grounds potentially occur with conspecifics and hetero-specifics (involving timing of breeding, use of similar habitats). It is also well known that fish that are typically used in Atlantic salmon aquaculture are selected for particular traits, and are designed for efficiency in an aquaculture environment (growth rate, disease resistance, flesh quality) but not necessarily for survival and success in the wild. Selection for traits such as growth rate (early spurt in growth) could provide farm fish with an advantage at a given life stage, but might also hinder their overall survival. Changes in endocrine regulation that influence behaviour, sensitivity to risk, and overall levels of aggression have potential effects on the performance of the wild populations. Studies by several researchers indicate that there is potential for negative impacts on wild populations, upon the introduction of farmed fish into those environments. The exact mechanism is not clear, but declining productivity and the displacement of wild fish by the presence of farmed fish was indicated.

Another participant pointed out that all studies of ecological interference of farm escapes on wild populations are within species, and wanted to know if there are any studies of the effects of Atlantic salmon introduced into wild populations of any Pacific salmon (one such study was noted). Research findings suggest that there is likely sufficient niche overlap with depressed steelhead populations in some locations where there is a niche open for Atlantics. Participants pondered whether recovered steelhead would out-compete Atlantics, or the reverse. Questions were also raised as to whether Atlantics could sustain feral populations, without continual escapees to bolster the population. So far, adult Atlantics have been noted in eighty rivers in BC, with juveniles seen in three.

Farm salmon grow faster in farm but also wild environments, they reduce the productivity of local wild populations, and displace wild fish. Although most studies have occurred over short time periods, research findings indicate that escapees would likely have a negative effect on wild stocks.

The subject of how SLICE may affect shellfish (prawns, shrimp, clams, etc.) was discussed at length. The local community is concerned about apparent discoloration of important clam gardens, and whether salmon farming (chemical use) is affecting clams.

Ecosystem concerns also include the potential consequences of depressed salmon populations on bears, eagles and other birds, and the health of a river's riparian zone (marine nutrient from salmon). 'Far field effects' of mercury transport (in fish feed) and subsequent reports of elevated levels of mercury in rockfish were noted. Local research is also underway on anomalies in flatfish (eye parasites, growth) possibly also caused by 'far-field effects' of salmon farms.

Management Tools

Disease/parasite control

Sea lice

Much of the discussion around disease and parasite control focused on the use of SLICE, the favored sea lice treatment in all countries culturing salmon. In the European Union, SLICE has also been administered experimentally to wild salmonid smolts before they swim to sea, with significant improvements in survival being observed. SLICE has a reported efficacy of 89-93%, five to six weeks after use, but substantial concerns were raised about the potential for sea lice to develop resistance to SLICE. SLICE replaced Ivermectin in many jurisdictions around 2000, after lice became resistant to Ivermectin. There has been recent evidence (e.g. in Ireland and Norway) of SLICE "treatment failures." It is predicted that alternative treatments will be needed. The value of synchronizing treatments (common in the EU) and the frequency of treatments were also discussed, with a participant noting that too-frequent treatment will likely reduce the time that a drug will remain effective on lice. Ireland has also tried early winter treatments to lower lice levels before rising water temperatures and changes in salinity prompt lice production.

Most countries do not rely solely on SLICE or other treatments to control lice. Vaccines (e.g. EX) are also being developed, but with no working vaccines at present, lice control is achieved through chemical treatment as well as harvesting, whole bay fallowing, and separation of age classes

(no uninfected smolts put next to infected adults). In contrast, in Broughton farms (and elsewhere in BC) age classes of fish are often mixed. It was noted that switching to single generation sites has helped reduce the severity and frequency of lice outbreaks in EU countries.

In Scotland, fallowing is done between production cycles (production in the sea is between thirteen and twenty months). No nursery sites are used, and all grower sites are stocked at the same time with similar year class fish. Wild and farmed fish proponents are also working together in some areas of Scotland. In Europe wrasse (cleaner fish) can be used to reduce lice levels (no native wrasse exist in North America); wrasse may be effective when combined with chemical treatments in summer. Ireland monitors sea lice fourteen times per year, with inspections every two weeks in spring (the critical period for wild smolts). Ireland also has protocols in place for the level of lice, which are sensitive to the size of the farms and the carrying capacity of the bays. Despite monitoring and protocols, Ireland has lost large populations of sea trout and salmon, even though as juveniles they are much larger than wild juvenile salmon in BC. In BC the scale of the lice problem is significantly greater.

In Norway, attempts are also made to kill off most of the lice before winter, so that they propagate more slowly over winter. The idea is that the fjord is fairly empty of sea lice larvae when wild smolts pass by the farms. While this has not been totally successful, there have been good results overall. Norway also has an ongoing program to develop a louse vaccine (the only other vaccine for ectoparasties has been developed for ticks). Other efforts are underway in the EU to develop a strain of Atlantics that are less susceptible to parasites. A document on Norwegian efforts to control lice has recently been translated into English.

The potential for sea lice to develop resistance to SLICE in Canada was also raised, along with the notion that, with larger numbers of wild salmon (compared to the EU countries), lice might have a non-farm refuge, and thus the development of resistance would be slower than in Europe. Questions were raised on whether lice (especially at the larval stage) had natural predators and whether such predators would be affected by the chemicals used to treat lice.

Participants also discussed the possible benefits of area management and the use of single generation sites in British Columbia, and the current difficulties that industry faces in obtaining sufficient farm sites for such practices. A general overview of sea lice on Marine Harvest farms in 2003, 2004 and 2006 was provided. Of note were observed peaks of production of lice in late-winter and early-spring in each of these years, that peaks of louse production in 2003 were the lowest observed due to the 2003 provincial sea lice action plan, that louse control should have begun earlier to protect wild juvenile salmon, and that SLICE, once applied, killed 94% of the lice at two monitored farms. Furthermore, questions were raised about delays in applying SLICE once the three motile lice 'trigger' was reached, and the biological validity of this trigger number, especially given the exceptionally small size and apparent vulnerability of pink and chum salmon to lice.

Questions also arose about the environmental fate of SLICE, particularly its potential impacts on shellfish. A five-year Scottish study on the ecological effects on SLICE indicated that there are extremely low and nearly undetectable levels of this chemical beyond a very short distance from the farm, and no SLICE was detected in phytoplankton, zooplankton, or crustaceans. A Canadian study showed that SLICE in high concentrations in a laboratory setting can cause premature molting in lobsters. It was suggested that we should improve programs to monitor the fate of SLICE.

The Irish Experience

The experience from Ireland points to the need for British Columbia to establish management regimes that do not rely solely on SLICE or other in-feed treatments. At a minimum, this management regime should consider:

- Establishment of protocols which specifically refer to sea lice monitoring and control;
- Separation of generations is imperative (no smolts placed beside growers);
- Annual fallowing of farm sites;
- Early harvest of two-sea-winter fish;
- Synchronous treatment of farms in the same geographic areas;
- Consideration of tidal effects on disease transfer (e.g. the separation distance of farms and wild fish established according to tidal excursion distances, not randomly-chosen distances).

Coastal zoning and area management

Is coastal zoning a possible option in Canada to control impacts of salmon farms on wild salmon? The answer to this question is difficult as Broughton-area First Nations are opposed to new sites needed by industry for this strategy to be tested. These First Nations are concerned that their territory has more than 100 productive salmon streams, which they feel severely limits acceptable locations for farms. The socio-economic impacts to local communities of the downturn in the wild salmon fishery were also raised as an issue around allowing new sites, and some participants were more interested in recovering local wild stocks, rather than accommodating the industry. The issues of separating wild from farmed salmon, either through technology or farm location, and how many farmed fish can be sustained in the Broughton, remains unresolved.

Norway now has six major salmon fjords where fish farms are not permitted, although it is too early to assess the effectiveness of this particular zoning experiment. Norway is particularly concerned about potential genetic impacts of escaped Atlantic salmon and zoning was driven more by this concern than sea lice issues. Farms are generally more accepted by the public in Norway, and stakeholders have been involved with government to determine where farms should be located with respect to Norway's 650 rivers. Based on these data the government of Norway determined the most appropriate areas for fish farms. The whole process took ten years.

Iceland got government and public buy-in to its extensive coastal zoning in only two years (see Sigurdur Gudjonsson abstract above). The process was strongly driven by wild fish and economic interests, and the farming industry was not present during the negotiations.

Enforcement/ Reporting

Some participants raised concerns about the enforcement and reporting aspects of fish farming in the Broughton. They did not know if enforcement (e.g. mandated lice levels) was working, and expressed frustration at a perceived lack of information on fish farming operations and impacts. Suggestions were made to increase transparency, communications, and access to farm and monitoring data.

The adequacy of waste management of Broughton farms was also discussed. Is enforcement limited to the immediate farm site? Are 'far-field' effects adequately considered/monitored (discussed earlier in ecological interactions)? How can we improve regulations? These and other questions arose around this issue, and it was suggested that all of these concerns must be taken into the context of what's happening to salmon throughout the North Pacific.

There are problems with salmon production in the North Pacific. Why are we seeing the largest production and catches of Asia and Alaskan pink and sockeye and Japanese chum salmon, while Canada has had some of the poorest salmon survival ever measured? Even after fifteen years of greatly reduced fishing, why have they not recovered? North Atlantic cod is another example – what is going on? A major effort needs to be put into climate impacts on the North Pacific and coastal British Columbia.

Information Gaps and Research Direction

Broughton ecosystem research program

Larry Dill and Don McQueen described an ambitious research program being funded by the BC Pacific Salmon Forum (PSF), whose mandate includes improving understanding and management of wild salmon stocks, and ensuring that aquaculture is sustainable. The PSF relies on a Science Advisory Committee and intends to fund a major package of Broughton research related to aquaculture in 2007 and 2008. The Broughton Ecosystem Research Program would spend $1.8 million over two years (with additional outside funding likely) to assess potential interactions between farmed and wild salmon, with a focus on sea lice impacts.

The program will involve all interested parties, including government, academics, industry, non-profit organizations, First Nations, and others. The first question to be addressed is: Do wild fish pick up sea lice from farms? Additionally: Do increased amounts of sea lice (if any) have impacts on those individual fish in terms of their physiological condition

(vulnerability to predation, competitive ability, disease)? And if so, does that have implications at the population level? These three questions are linked.

The PSF is also concerned about confidence in the research results. All researchers will be able to look at the same data, and the largest (government) data base on fish and lice will be analyzed independently, as well as compared to recent research done by non-government scientists and at a different spatial scale. The program will integrate oceanographic parameters (including current and wind data), escapement data (numbers of fish returning to local rivers), and attempt to track fish from individual rivers and calculate egg-to-smolt and smolt-to-adult survival rates of wild salmon.

A manipulation experiment is also planned. In one of the two years of the program, maybe both, PSF-sponsored researchers hope to fallow portions of the Broughton Archipelago, pending negotiations with First Nations, the Coastal Alliance for Aquaculture Reform, and Marine Harvest. Further research will be sponsored on morbidity/mortality of infected juvenile salmon, in both field and laboratory situations.

Further dialogue among participants focused on suggested research topics, including the integration of an oceanographic program to help sort out lice and fish distributions (temporal and spatial) around farms. The use of sentinel cages might be a key component in this study, and researchers might consider using Atlantic salmon in cages (smolts would be more readily available than wild salmon). Using Atlantic salmon would also allow researchers to use larger mesh cages which do not foul as quickly as smaller mesh sizes required for confining smaller Pacific salmon. Marine Harvest has also expressed an interest in this study. Control sites would be needed, within the region or elsewhere (e.g. the Bella Bella region of BC's Central Coast). A question was raised if sticklebacks might also be used in sentinel cages. Related research in other parts of BC was briefly mentioned.

Questions were raised about how to resolve the population impact question, particularly through a manipulation experiment. A suggestion was made to fallow half of the Broughton to see how this manipulation would affect the overall population. It was recognized we might have to settle for less ambitious fallowing options, and First Nations are expected to play an active role in this project.

Public Forum

Introduction to Public Forum

"*The whole world has heard of the Broughton Archipelago, about its salmon farms and sea lice, about the situation of its wild salmon, especially the pinks and chum. The story of the Broughton is a story that is actually being repeated elsewhere in the world in other countries. There are other places where we have failed to take care of the wild salmon to the extent that we should have. While there is a certain degree of comfort in knowing that the problem is shared, the real comfort comes from knowing that others are working to try and find solutions to the problems, and those solutions may actually help you in solving your own problems, or at least in adapting them in a way that can bring solutions to your own problems. These scientists from Iceland, Norway, Ireland, the United Kingdom and Atlantic Canada bring problem solving approaches that derive from their own cultures and experiences. They are here to share the lessons that they have learned, the things that have failed, the things that have worked. From that we may be better able to solve some of the problems. What we do know is that the wild salmon/farm salmon issue in the Broughton has got to be solved.*

There are at least three benefits that we are hoping to come out of this meeting. The first one is what your Chief calls "science that cannot be dismissed". The second has already been achieved from the hospitality and cordiality that we have received as well as the tour - that is, the active engagement of the world scientific community in your problem. Every one of the scientists that is here will be taking back with them in their heart a part of the Broughton Archipelago. They will be thinking about it as they conduct their own research and they will be bringing forward what they have learned to try and help you in the future. The third outcome that we are hoping to come from our workshop is to incorporate some of your knowledge of your community." Dr. Fred Whoriskey, Chair

A local participant asked:
"How would you address the problems that we have in the Broughton with the open net fish farms and the concerns that we have about sea lice and habitat degradation?"

Response from the panel.
It is apparent from the farm layout and the physical properties of the Broughton that there will continue to be impacts on wild fish. The fallowing approach taken in 2003 should be repeated to reduce the impacts on outmigrating juvenile pinks. The onus should be on the industry to ensure that sustainable practices are employed. Separation of year classes is also important - if there were just smolts on the farms then it might be beneficial to the wild runs. "The peer-reviewed science is already there - but in some cases it is misrepresented or completely ignored."

Before positive change can be made all stakeholders and government bodies should be in dialogue. Everyone has to be at the table and all parties must participate in effective development of the management planning. Also, citing criteria must be looked at. "In Norway, we no longer discuss whether sea lice have an impact on wild fish. It is very clear that sea lice do have an impact. It is also very clear and understood that most of the sea lice originate in the fish farms."

There are real challenges to getting the dialogue going

however. Industry does not appear to have effectively involved local people in development plans. The involvement of local people is of primary importance.

A participant noted the following changes that may be associated with the introduction of fish farms in the Broughton including: depression of pink salmon runs, closures of the commercial fisheries, negative effects on clam beaches and cod near fish farms also appear to be lice-infested.

Another participant documented the eutrophication of clam beds in the territory which the local community believes is associated with the effluent from salmon farms. They noted that the regulatory regime deals with waste management of farms, assessing only 'near field' effects of operations within the tenure. The negative changes on the clam beds demonstrate the need for assessment of 'far field' effects. "The government wants to just look at what is underneath the pens, yet across the bay there are clear signs of the negative aspects of this industry."

There is a suggestion that the coast of British Columbia could be managed by a number of 'Regional Management Boards'. There is a historical opportunity here for First Nations communities to take leadership so that in the future decisions will incorporate local knowledge and be based on meaningful consultation and dialogue.

Summary of Breakout Discussions

Assessing Risk and Future Directions

The consensus from the break-out groups was that current fish farm management and regulatory practices pose substantial risks. Concerns were not restricted to direct impacts of sea lice on depressed populations of pink and chum salmon, but extended to broader biological and socio-economic impacts. Specific examples include the following:

- food-chain impacts of reduced abundances of wild salmon on top predators,
- impacts on benthic communities,
- impacts on the area clam beds,
- evolutionary responses to new selection pressures associated with fish farms,
- lost opportunities for commercial fishing, sports fishing, and ecotourism,
- degradation of traditional sources of sustenance for local residents, of special significance to First Nations, and
- increased social disharmony.

Participants highlighted several special challenges in British Columbia. These included:

- the extremely small size of pink and chum salmon as they enter the marine environment,
- the fact that pink, chum, and sockeye salmon migrate up the coastal shelf rather than directly out to sea, and
- the polarization with respect to regulatory management of the fish farming industry.

Options for ameliorating this unacceptable situation were discussed. Among these, a complete elimination of fish farming and an immediate move to closed containment were considered impractical. Cooperative area management was generally viewed as a more practical solution.

With respect to salmon, the following specific goal was articulated: to improve the management regime not merely to protect against extirpation of spawning populations, but to promote their abundance. Participants generally agreed that there could be no guarantees of success, and that other risk factors in addition to fish farming needed to be addressed. Nonetheless, with this caveat, the goal was not contested.

The following specific issues and strategies were brought forth (*with associated research needs brought forth in the discussion noted in italics*):

1. Scientific Consensus:
   The need for agreement on the science associated with fish farm impacts was seen as critical.
2. Improved access to critical information:
   Participants also expressed a similarly critical need for more open, timely access to such information as lice levels on farms and results from government surveys and independent scientific studies. (Editor's note: Where necessary to protect proprietary interests, confidentiality agreements could be negotiated, and, where feasible, access could be limited to data aggregates or coded data.)
3. Focus on juvenile migration season:
   It was noted that management regulations need to take into account the critical importance of the juvenile migration season. Triggers for sea lice treatment on farms, for example, need to be tightened in lead-up to this critical season.
4. Specific tools:
   a. Zoning:
      Participants noted the particularly stringent zoning regulations imposed in Iceland and similar, recent developments in Norway. Zoning was frequently discussed as a valuable tool for protecting sensitive areas on the British Columbia coast. (*Research Needs: Information on juvenile migration routes, sensitive habitats, and interactions with potentially vulnerable wild salmon populations.*)
   b. Siting criteria:
      There was considerable discussion of potential farm siting criteria, aimed at protecting particularly vulnerable portions of migration routes and other sensitive local areas from fish farm impacts. Specific suggestions included siting farms well away from areas frequented by particularly critical pink and chum salmon shortly after their arrival in the marine environment, and major juvenile migration routes for economically valuable wild salmon populations. Participants also commented on practical limitations associated with locating fish farms in, for example, open-ocean sites that would be well away from coastal migration routes. (*Research Needs: Information on juvenile salmon migration routes and the influence of fish size and species on vulnerability to lice infestations.*)
   c. Placement of farm fish by age:
      Participants were reminded of European successes in moving fish that were about to be harvested, and hence not treatable for lice, away from juvenile salmon migration routes and holding areas.
   d. Area quotas:
      Some participants supported the delineation of area-wide quotas for fish-farm stocking levels. Within these limits, it was suggested, farm managers could then be given more freedom to move the fish to a new site during the spring migration season with guarantees to others that this would not simply lead to a net increase in the number of farm fish stocked in the area.

e. Harvest timing:
   Another recommended strategy was to schedule harvest times for farms located on or near juvenile pink and chum salmon migration routes well away from the juvenile migration season. Then the fish could be treated for lice as needed in advance of, and during, the juvenile migration.
f. Synchronized treatments:
   Participants recognized that it could be necessary to treat all farms in an area, such as along a juvenile salmon migration route, to protect the wild salmon population – an important advantage of area management policies. (*Research Needs: Information on the dispersal of planktonic-stage sea lice away from the farms and on the juvenile salmon migration routes.*)
g. Fallowing experiments:
   Support was expressed for fallowing experiments in generating insight on population impacts of fish farms on marine survival of wild salmon. (*Research Needs: A commitment to ongoing fallowing experiments, designed according to solid, scientific principles.*)
h. More lice treatment options:
   Participants commented on the dangers associated with heavy reliance on individual chemical treatments, such as SLICE for controlling sea lice infestations. *Research aimed at providing other treatment options, such as a vaccine, was recommended.*
i. Evaluate triggers:
   It was argued that triggers for deployment of lice treatments should be tied to potential impacts on wild salmon and other ecosystem impacts.
j. Adaptive development of triggers:
   Some participants noted that European triggers are being developed adaptively as information on their efficacy in protecting wild salmon evolves. It was recommended that triggers be developed for British Columbia similarly, taking into account known and predicted differences between the situations in Europe and British Columbia and with a commitment to alter these triggers as more information on their efficacy is developed.
k. Firm adherence to regulations:
   Participants also commented on the need for firm adherence to regulations, with solid enforcement where necessary.

Throughout the meeting, there were repeated comments that a lack of firm, scientific certainty could not be used to delay management changes aimed at protecting depressed wild salmon populations. Although ongoing research is needed to generate improved management and regulatory procedures, there was general consensus that there was sufficient scientific evidence to warrant invocation of a precautionary approach.

Biosketches

Michael Berry is a BC Registered Professional Biologist who has lived in Alert Bay and worked on local fisheries-related projects for over 30 years. Michael's area of interest(s) is in conservation of wild salmon and other fishery resources. In his consulting practice he is involved with freshwater salmon habitat restoration, salmon enhancement, marine resources impact assessments and marine resources inventory and mapping. Michael is a Councilor for the Village of Alert Bay, a Project Manager for the Inner Coast Natural Resource Centre and the Chair of the Alert Bay Marine Research Society; he is also one of a 3-person team (along with Larry Dill and Don McQueen) who are assisting the BC Pacific Salmon Forum in coordination of the farmed/wild salmon interaction research program.

Karin Boxaspen received her formal education in Biotechnology. She has worked on sea lice related problems since 1990. She received her doctorate degree in the study of natural biocide treatment in farms. She now works with experimental sea lice biology, modelling dispersal of larvae from farms and ecological consequences of aquaculture. She is currently the Coordinator for this work within the Institute of Marine Research, Norway Institute of Marine Research in Bergen.

Brendan Connors is an MSc. candidate in the Biology department at Simon Fraser University. He has been involved in research in the Broughton Archipelago for the past 4 years. His current research focuses on understanding how parasite behaviour influences the distribution of sea lice among hosts.

Natasha Damiano* is a Research Assistant with Genome BC and active in organizing and facilitating events that engage the public, academics, scientists and other interested parties in discussions of the various economic, ethical, environmental, legal and social issues relevant to genetic science. She is also responsible for reporting on GE3LS events for the Genome BC website and for keeping up to speed with current GE3LS -related activities outside of Genome BC.

Willie Davidson is a Professor in the Department of Molecular Biology and Biochemistry at Simon Fraser University. His research interests are broad, but are all in the general field of molecular evolution. His studies in population genetics include Atlantic salmon, and Arctic char as well the interactions between, and the hybridization of, brown trout and Atlantic salmon. For the past five years he has been involved in salmonid genomic research, and he is currently a co-PI of the Genome Canada funded Consortium for Genomic Research on All Salmonids Research Project (cGRASP).

Larry Dill is a Professor in the Department of Biological Sciences at Simon Fraser University and Director of SFU's Behavioural Ecology Research Group. He is author of well over 100 papers on animal behaviour and ecology, mostly dealing with marine animals, from invertebrates to whales. His current research focuses on the role of behaviour in predator-prey interactions and ecosystem processes (in W Australia) and on salmon-sealice interactions in the Broughton. He is a co-coordinator of the Pacific Salmon Forum's Broughton Ecosystem Research Program.

Ian Fleming is a Professor and Director of the Ocean Sciences Centre of Memorial University of Newfoundland. His research integrates perspectives from ecology and evolution with fishery and conservation biology, and his areas of expertise include fish behavioural and evolutionary ecology, reproduction, life history and population biology. He has worked extensively on the management and conservation of wild fish populations, particularly salmon, and the ecological interactions with marine finfish aquaculture. He has also served in a number of capacities related to fisheries research and policy, including review panels for Fisheries and Oceans Canada (DFO) on the Status of Atlantic salmon (2006) and for National Research Council (US) on the Status of Atlantic Salmon in Maine (2002-4), and the DFO Aquaculture Collaborative Research & Development Program Regional Committee (2006).

Jennifer Ford has been doing research and advocacy around fisheries and marine conservation in Nova Scotia for several years. She has recently completed an MSc thesis entitled "Demonstration of an impact of salmon farming on survival of wild salmonids in the North Atlantic and Pacific, using population dynamics data" with Dr. Ransom Myers at Dalhousie University.

Neil Frazer is a professor of geophysics in the School of Ocean and Earth Science and technology at the University of Hawaii at Manoa. He has a background in physics, especially theoretical seismology, underwater sound, and nonlinear inversion. His hobby is camping in the remoter parts of the coasts of BC and southeast Alaska, the territory of field biologists like Alexandra Morton and Tom Reimchen. Physics and ecology have much in common, and the sea lice problem is a good example of this. For a physicist, it is a trivial exercise to show that adding farm fish to a system of wild fish and parasites must cause sea lice levels to rise and wild fish to decline, but predicting the magnitudes of the changes is an interesting problem in dynamics--a problem that Neil has been working on for several years in collaboration with Marty Krkosek and Mark Lewis of the University of Alberta.

Patricia Gallaugher is Director of Science Programs in Continuing Studies and the Centre for Coastal Studies at SFU. She is a physiologist and has published on various aspects of oxygen transport in salmonids. For her most recent research addressing revival of bycatch in BC's commercial salmon fishery, she was co-recipient of the Murray Newman Award for Excellence in Aquatic and Marine Conservation Research (2002). She currently focuses on the integration of science and local knowledge with implementation of policy with respect to coastal and ocean resources. Since 1998, the results of numerous dialogues/workshops and research under her direction have been published in the series, Speaking for the Salmon.

Paddy Gargan is the Senior Research Officer with the Central Fisheries Board, at the Swords Business Campus, Swords, Co. Dublin. The Central Fisheries Board has responsibility for the management, development, protection and research of salmon and sea trout stocks in freshwater. The Board has been concerned regarding the potential impact of sea lice from marine salmon farms on wild salmonid stocks. Gargan has been involved in research into the impact of sea lice from marine salmon aquaculture on sea trout stocks on Ireland's west coast since 1990. In more recent years he has undertaken the Irish research on the impact of sea lice on migrating salmon smolts as part of a European Union funded SUMBAWS programme. He sits on a number of national committees relating to the licencing, regulation and management of both salmon aquaculture and wild salmonid fisheries.

Allen Gottesfeld has a background as a professor of hydrology and watershed management. Since returning to the Skeena Valley to direct First Nations fisheries research in 1999, he has been working in salmon ecology and stock assessment. He has been involved in sea lice research to determine the abundance of sea lice on the north coast and the pattern of distribution in time and space. The 2006 research program focused on the natural source of L.salmonis infestation and the means of transfer.

Sigurdur Gudjonsson has been working at the Institute of Freshwater Fisheries in Iceland first as a scientist and since 1997 as the director. The Institute's role is to do research and development regarding freshwater fisheries and aquaculture. The Institute is governmental and works closely with the authorities, i.e. the Directorate of Freshwater Fisheries (now the Agricultural Authority) and the ministries regarding management of the resources. Gudjonsson's work has mainly been with Atlantic salmon studying life history strategies and river classification as well as salmon population genetics and in later years focused on fisheries management and management of the freshwater fish resources. The interaction of aquaculture and wild salmonids has taken much time and effort to find solutions in order that these can co-exist. His latest research work involves using DST tagged smolts to map the routes of salmon at sea.

Bror Jonsson has more than 30 years of experience in research on population ecology in salmonids. He has been chief scientist for fish ecology at the Directorate for Nature Management (1985-1988), and research director at the Norwegian Institute for Nature Research (1988-2002), where he now is senior scientist. He has published 170 scientific papers and more than 200 reports and popular science papers on the ecology of salmonid fishes with special emphasis on population ecology, sea ranching, ecological effects of escaped salmon from fish farms and population effects of climate change.

Sunil Kadri has spent more than 20 years working in aquaculture within the fields of research, development and the industry itself. Within industry, Kadri has for the past decade been involved in the successful business development of novel technologies which have contributed to improvements in production, environmental impact and fish welfare; furthering sustainability of intensive aquaculture. His academic pursuits have included behavioural studies of salmon, trout, sea bream and sea bass; and present projects involve cod and carp. He has also recently been working with philosophers and social anthropologists in both Europe and North America, providing a fresh perspective on the social, moral and regulatory context into which aquaculture research and industry practices must fit. He holds an Honorary Research Fellowship at University of Glasgow and operates a consultancy business: Aquaculture Innovation. His active involvement in both industry and academia provides for two way knowledge transfer which has been a very important aspect of his career.

Ben Koop is a molecular evolutionary biologist with interests in immunology, cancer, population genetics and genomics. He is a professor and Canada Research Chair in the departments of Biology and Medical Sciences and is the Director of the Centre for Biomedical Research at the University of Victoria. He co-directs the consortium for Genomic Research on All Salmon Project (cGRASP) and his research has resulted in the identification of most of the genes in salmon and the production of a widely used 16,000 gene chip.

Martin Krkosek is a PhD student at the Centre for Mathematical Biology at the University of Alberta. His research focuses on how aquaculture affects the ecology of sea lice and salmon and how this challenges salmon conservation. Marty works in the Broughton Archipelago, where he conducts fieldwork and field-based experiments to collect data on spatial patterns of sea lice infestation of juvenile salmon and the effects of infection on juvenile salmon survival. These data are then analyzed and synthesized using mathematical models of sea lice transmission and salmon migration and survival. With these methods he and his collaborators have been able to estimate the magnitude and spatial extent of sea lice transmission from farm to wild salmon and the subsequent mortality of wild salmon.

Mark Lewis is a mathematical biologist specializing in spatial ecology and dispersal. His expertise relevant to the summit is on modelling the distribution of sea lice in the Broughton and assessing the impact of sea lice on wild salmon mortality. His work on this area has been in collaboration with his graduate student, Marty Krkosek, colleague, John Volpe, and others. He is Director of the Centre for Mathematical Biology at the University of Alberta and is Canada Research Chair in Mathematical Biology.

Don McCubbing graduated from the University of London, England, with a Masters degree in Aquatic Biology in 1988 and worked with Wessex Water plc as an Inland Waters Biologist from 1989 through 1992, followed by five years as a Fisheries Technical Officer and Area Fisheries Manager with the Environment Agency in the North West of England. He moved from the UK to Canada in 1997 and instigated Instream Fisheries Research, a company specializing in studies of steelhead and salmon ecology, conservation and restoration. These projects include the 30-year study

of steelhead population dynamics on the Keogh River, Vancouver Island. Don also has over 15 years experience in the application of resistivity fish counting technology and is currently managing projects in British Columbia, Ontario, Oregon and Alaska.

Don McQueen is an Emeritus Research Professor of Biology with York University and an Adjunct Professor of Biological Sciences with Simon Fraser University. He is a Member of the Pacific Salmon Forum (PSF) Science Advisory Committee and a Member (with Dill and Berry) of the PSF Broughton sea lice research coordinating team. His research interests include limnology and fisheries, aquatic food web analysis and large-scale whole-lake food web manipulations involving fertilizer additions and piscivore removals. McQueen is currently working with the Okanagan First Nation to evaluate the addition of juvenile sockeye salmon into Skaha Lake and the invasion of Mysis relicta into Osoyoos Lake. He is also currently working with the 'Namgis First Nation on the fertilization of Woss and Vernon Lakes to enhance sockeye salmon growth and subsequent marine survival.

Alexandra Morton is a Registered Professional Biologist in British Columbia. Morton moved to the Broughton Archipelago in 1984 to study natural history and acoustics of killer whales. In 1993 Acoustic Harassment Devices used to repel harbour seals from salmon farms displaced the killer whales she was studying. Morton's research gradually shifted to study of impact of salmon aquaculture. In 2003, she started taking in graduate students interested in working on sea lice and in 2006 her home became Salmon Coast Field Station, dedicated to offering inexpensive access and a base camp to researchers working on the science required to make valid marine conservation decisions. Alexandra was the recipient of the 2006 Murray Newman Award for Significant Achievement in Aquatic Conservation.

Craig Orr is a behavioural ecologist, salmon conservationist, and the executive director of Watershed Watch Salmon Society. Craig specializes in science outreach and since 1998 has helped Simon Fraser University organize more than two dozen workshops for the Speaking for the Salmon series. He has also published popular and scientific papers on sea lice and ecosystemic effects of salmon farms, and currently leads the Coastal Alliance for Aquaculture Reform's collaborative sea lice monitoring and research efforts with Marine Harvest Canada.

Stan Proboszcz is a fisheries biologist with Watershed Watch Salmonid Society and a member of the Coastal Alliance for Aquaculture Reform (CAAR). Stan has been involved in summarizing lice monitoring data from the 2006 Broughton Archipelago collaborative monitoring program between Marine Harvest Canada (MHC) and CAAR. He also works on various other aspects concerning aquaculture and wild salmon conservation as detailed in the framework agreement between CAAR and MHC.

John Reynolds joined SFU in 2006, taking up the BC Leadership Chair in Salmon Conservation. He is on the Science Advisory Committee of the Pacific Salmon Forum, which was established by the BC Premier to investigate interactions between wild and farmed salmon. He is co-supervising an MSc student working in the Broughton on interactions between sea lice, sticklebacks, and juvenile salmon.

Brian Riddell is Division Head of Salmon and Freshwater Ecosystems in the Science Branch of Fisheries and Oceans Canada based at the Pacific Biological Station in Nanaimo. His research interests include population biology and genetics (quantitative and population) of Pacific salmonids; population dynamics, life history, and fishing mortality estimates for Pacific salmon, in particular chinook salmon; appropriate management policy for Pacific salmonids; and formulation of science-based policy for conservation and utilization of Pacific salmon. During 2002-04, as Science Advisor to the Pacific Fisheries Resource Conservation Council (PFRCC), Riddell authored or co-authored reports on the Broughton Archipelago Pink Salmon advisory, the PFRCC Aquaculture advisory, Stock Assessment for Central and Northern BC, a technical review of over-escapement, and an Advisory on a proposed Aquaculture Forum for BC.

Rick Routledge, Chair, Statistics and Actuarial Sciences at SFU, has been collaborating with Alexandra Morton, Marty Krkosek and others on sea lice research in British Columbia. This highly controversial work has provided evidence that sea lice infestations on salmon farms spread to passing juvenile pink and chum salmon, and that lice loads commonly observed on these notably small wild fish close to the farms can cause a substantial increase in short-term mortality. Routledge has also been studying the juvenile migration of a severely
depleted sockeye salmon population on the British Columbia Central Coast. Evidence available to date points to changes to early-spring river flows as a major contributing factor to the decline - changes which are in turn linked to increasing atmospheric carbon dioxide concentrations.

David Secko* is a science journalist and postdoctoral fellow at W. Maurice Young Centre for Applied Ethics at the University of British Columbia. His writing appears in publications like The Scientist, The Canadian Medical Association Journal and The Science Creative Quarterly. He obtained his Ph.D. in Microbiology and Immunology and a Masters of Journalism in 2006 at the University of British Columbia. He is currently a GE3Ls researcher on the consortium for Genomic Research on All Salmonids Project (cGRASP) and is exploring methods of democratic public engagement.

Kate Sullivan* joined the Department of Anthropology with California State University L.A. in September 2005 after completing her Ph.D. in Anthropology at the University of California Santa Barbara in December 2004. Her research investigates social and discursive relations of power in transnational public forums focused on the development and governance of marine resources. She queries the intertwined roles of mass media and environmental relations in the context of globalizing economic and cultural forces. Her research

and publications contribute to a growing body of studies that critically examine the constitutive relations of power in environmental politics. Professor Sullivan's overarching goal is to explore the contingent and evocative notion of democracy, particularly as it is manifested in quotidian practices and relationships. Professor Sullivan conducts ethnographic field research in British Columbia, Canada, Washington State, U.S.A., and Santiago and X Región de Los Lagos, Chile. She has also done ethnographic fieldwork in the coastal fisheries of Texas.

Jonathon Thorpe is a retired salmon biologist, having spent the greater part of his working career as a research scientist with the UK Government, at the Freshwater Fisheries Laboratory, Pitlochry, Scotland. His principal interests have been in developmental biology and behaviour of salmonids, chiefly, but not restricted to, Atlantic salmon. Since retiring from Pitlochry laboratory in 1995 he has been a Visiting Professor in the Institute of Biomedical & Life Sciences at the University of Glasgow, and after ten years as Editor of the Journal of Fish Biology he has just completed two years as President of the Fisheries Society of the British Isles.

Martin Weinstein is a natural resources scientist, trained as a biological oceanographer and an animal ecologist at McGill University. His work with First Nations and governments across northern Canada and on the B.C. coast during the last 30 years bridges the realms of bio-physical and social sciences. His research has focused on the socio-economic aspects of resource management, and the relationship of long-established communities to their environment and renewable resources. For the last 5 years he has lived in Alert Bay, working as the 'Namgis First Nation's Aquatic Resource Coordinator. He is an Adjunct Professor at Simon Fraser University's School of Resource and Environmental Management.

Fred Whoriskey is the Vice-President of Research and Environment at the Atlantic Salmon Federation. His research interests are in fish biology and ecology, and the impacts of exotic species on native ecosystems. He is author or co-author of over 60 papers in refereed journals, as well as many technical reports and editor of two books. He has also been heavily involved in public policy issues, especially with regards to environmental impact assessments, and has worked extensively in public education. Fred served on the Board of AquaNet (Canada's National Centre of Excellence in Aquaculture), Chairs the Board of the Huntsman Marine Science Centre, and is Co-Chair of the IUCN Salmonid Specialist Group.

* Observer

The Speaking for the Salmon series examines issues impacting the survival of wild salmon in British Columbia. Projects in the series include workshops, think tanks, proceedings and video presentations.

Past Topics include:

- Groundwater and Salmon, March 2007
- Summit of Scientists on Aquaculture and the Protection of Wild Salmon, January 2007
- Getting the Missing Story Straight: Part II A Ten Year Retrospective on Fraser Sockeye Salmon, November 2005
- Scientists' Roundtable on Sea Lice and Salmon in the Broughton Archipelago Area of British Columbia, November 2004
- A Community Workshop to Review Preliminary Results of 2003 Studies on Sea Lice and Salmon in the Broughton Archipelago Area of British Columbia, January 2004
- World Summit on Salmon, June 2003
- Summit of Scientists: Nutrients & Salmon Production, November 2002
- Summit of Scientists: Sea Lice, July 2002
- Aquaculture and the Protection of Wild Salmon Follow-up to March 2000, October 2001
- Hatcheries and the Protection of Wild Salmon, June 2001
- Rivers Inlet: An Eco-System in Crisis, November 2000
- Summit of Scientists: A review of the DFO Wild Salmon Policy, May 2000
- Aquaculture and the Protection of Wild Salmon, March 2000
- Pacific Coast Salmon: Status of Stocks and Habitat, June 1999
- Thompson Steelhead: A resource in crisis?, October 1998
- Summit of Scientists on the Scientific Underpinning of the 1998 Management Decisions for Pacific Coho Salmon–Consensus report, June 1998
- Selective Harvesting, May 1998
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