Second Session, 38th Parliament

REPORT OF PROCEEDINGS (HANSARD)

SPECIAL COMMITTEE ON

SUSTAINABLE AQUACULTURE

Vancouver

Tuesday, December 5, 2006

Issue No. 32

ROBIN AUSTIN, MLA, CHAIR

ISSN 1718-1054

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SUSTAINABLE AQUACULTURE

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Chair:	* Robin Austin (Skeena NDP)
Deputy Chair:	* Ron Cantelon (Nanaimo-Parksville L)
Members:	* Al Horning (Kelowna–Lake Country L) Daniel Jarvis (North Vancouver–Seymour L) * John Yap (Richmond-Steveston L) * Gary Coons (North Coast NDP) * Scott Fraser (Alberni-Qualicum NDP) * Gregor Robertson (Vancouver-Fairview NDP) * Shane Simpson (Vancouver-Hastings NDP) * Claire Trevena (North Island NDP)
	**denotes member present*
Clerk:	Craig James
Committee Staff:	Brant Felker (Committee Research Analyst)

Witnesses:	Dr. Richard Beamish (Fisheries and Oceans Canada) Dr. Kenneth Brooks (Aquatic Environmental Sciences) Dr. Simon Jones (Fisheries and Oceans Canada) Martin Krkošek Alexandra Morton (Raincoast Research Society) Dr. Rick Routledge (Simon Fraser University) Dario Stucchi (Fisheries and Oceans Canada)

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SPECIAL COMMITTEE ON SUSTAINABLE AQUACULTURE

Tuesday, December 5, 2006
10:00 a.m.
Grand Ballroom D, Sheraton Wall Centre
1088 Burrard Street, Vancouver, BC

Present: Robin Austin, MLA (Chair); Ron Cantelon, MLA (Deputy Chair); Gary Coons, MLA; Scott Fraser, MLA; Al Horning, MLA; Gregor Robertson, MLA; Shane Simpson, MLA; Claire Trevena, MLA; John Yap, MLA

Unavoidably Absent: Daniel Jarvis, MLA

Others Present: Brant Felker, Research Analyst

1. Opening statement by the Chair, Robin Austin, MLA

2. The following witnesses appeared before the Committee and answered questions:

1) Dr. Kenneth M. Brooks, Owner and Central Scientist, Aquatic Environmental Sciences
2) Fisheries and Oceans Canada
   - Dario Stucchi, Physical Oceanographer, Institute of Ocean Sciences
   - Dr. Richard Beamish, Senior Scientist, High Seas Interactions Section, Pacfic Biological Station
   - Dr. Simon Jones, Research Scientist, Aquatic Animal Health, Marine Ecosystems and Aquaculture Division, Pacific Biological Station
3) Martin Krkošek, Centre for Mathematical Biology, University of Alberta
4) Dr. Rick Routledge, Chair, Department of Statistics and Actuarial Science, Simon Fraser University
5) Alexandra Morton, Raincoast Research Society

3. The Committee adjourned to the call of the Chair at 3:55 p.m.

Robin Austin, MLA
Chair

Craig James
Clerk Assistant and
Clerk of Committees

TUESDAY, DECEMBER 5, 2006

The committee met at 10:13 a.m.

[R. Austin in the chair.]

R. Austin (Chair): Good morning, and welcome. My name is Robin Austin, and I am the Chair of the Special Committee on Sustainable Aquaculture of the Legislative Assembly of British Columbia.

Today we have invited a group of scientists to appear to discuss some of the issues that have provoked a lot of controversy during our inquiry into sustainable aquaculture practices in British Columbia.

The topics of discussion today relate to sea lice infection, salmon farms, the Broughton Archipelago and the far-field and ecosystem effects of farm wastes, as well as other issues such as chemical treatments to control sea lice, the fallowing of sites and the impact between migratory routes and fish farm locations. We would like to thank our invited panellists for coming to what will most likely be a lively discussion.

This will be a unique format for a parliamentary committee meeting. Therefore, I would briefly like to provide an overview of the format and rules of this session.

We'll begin by allowing each panellist to introduce themselves and make reference to their expertise. We're going to give them around five minutes to do that. I will then read the questions previously shared with each panellist and ask each panellist to respond — again, with up to five minutes. Members of the committee will then be able to ask questions of any panellist after the panellists have responded to the questions.

It is expected that each of the questions will not exceed one hour of discussion. At the end of the session each panellist will be asked to provide a closing statement — again, up to five minutes. I'll be the moderator for this session and will do my best to keep the discussion on track and on time.

I would also like to outline a few rules for this session. Members of the committee shall not be permitted to offer their views, opinions or agreement with or opposition to any of the panellists or to engage any panellist in argument. Members may not interrupt a response by a panellist or a question by another member of the committee. Panellists may not interrupt another panellist during a response, and there can be no disturbance in the public gallery of any kind.

[1015]

I would also like to note that today's meeting of the committee is a public meeting which will be recorded and transcribed by Hansard Services. A copy of today's transcript, along with the minutes of this meeting, will be printed and will be made available on the committees website at www.leg.bc.ca/cmt/aquaculture. As well, an audio recording of today's meeting will be archived on this website.

Before we start, I would ask that each committee member introduce themselves, starting on my far right.

A. Horning: Al Horning, MLA for Kelowna–Lake Country.

J. Yap: John Yap, MLA for Richmond-Steveston.

R. Cantelon (Deputy Chair): Ron Cantelon, Nanaimo-Parksville.

C. Trevena: Claire Trevena, North Island.

G. Robertson: Gregor Robertson, Vancouver-Fairview.

S. Simpson: Shane Simpson, Vancouver-Hastings.

G. Coons: Gary Coons, North Coast.

S. Fraser: Scott Fraser, Alberni-Qualicum.

R. Austin (Chair): Now, just prior to the scientists having their five-minute opening statements, I'd like to go through the panel and ask each member of the panel to briefly state their name and affiliation for the record, starting on my right.

K. Brooks: My name is Kenneth Brooks, and I'm the owner and central scientist at Aquatic Environmental Sciences in Port Townsend, Washington.

D. Stucchi: My name is Dario Stucchi. I'm a physical oceanographer with the Department of Fisheries and Oceans at the Institute of Ocean Sciences in Sidney.

R. Beamish: My name is Dick Beamish, and I am the senior scientist at the Pacific Biological Station in Nanaimo.

S. Jones: My name is Simon Jones. I'm a research scientist at the Pacific Biological Station in Nanaimo.

M. Krkošek: My name is Martin Krkošek, and I'm a PhD student at the University of Alberta.

R. Routledge: I'm Rick Routledge, and I'm chair and professor of statistics at Simon Fraser University.

A. Morton: Alexandra Morton, director of Raincoast Research.

R. Austin (Chair): Thank you very much. I'd like to begin with our first panellist, Ken Brooks.

Presentations

K. Brooks: I've been working in assessing the environmental effects associated with aquaculture, both finfish and shellfish, for almost 20 years now. I represent the United States on two United Nations committees, GESAMP committees, which are developing recommendations for member nations dealing with the assessment and management of the environmental

response and effects of all types of nearshore marine aquaculture.

A lot of my work is focused on the effects of organic enrichment and inorganic metals in British Columbia and in Washington State. I started work up here in 1996 and have completed numerous very detailed studies that form the basis of the science that's used by the Ministry of Environment in developing their waste management program.

I'm currently reviewing all of MOE's data collected between 2000 and 2005 regarding benthic effects associated with salmon aquaculture and just last week submitted a draft assessment of that, which will help them in developing the five-year revision to their waste management policy.

D. Stucchi: As I said earlier, I'm a physical oceanographer. I've been studying the circulation in coastal waters of fjords of B.C. and the variations in water properties like temperature and salinity and chemical constituents like dissolved oxygen.

I've worked on this coast for over 30 years and have had the good fortune to work in many of the coastal areas of this province, ranging from the extreme south in Juan de Fuca Strait to Alice Arm in the northern extremity of this province.

I've conducted a number of research studies related to the various industrial effects and activities impacting on the marine environment, such as the discharge of mine tailings, pulp and paper mill effluent from several of the pulp and paper mills in the province and sewage discharges. Since about 2000 I have worked with the aquaculture industry in the Broughton region.

I've also studied coast-wide climate variations in some of the inlets of our coastline as well as looked at specific circulation studies in some of our large straits like Juan de Fuca Strait. Interestingly enough, in the late '70s I was involved with Dr. David Farmer at the Institute of Ocean Sciences when he started his pioneering work on the mixing processes over the sill in Knight Inlet at Hoeya Head.

[1020]

Since 2000 I'm back working in the Knight Inlet area, Broughton area, together with Mike Foreman, a numerical modeller, to help develop circulation models for that region and obtain observations to understand the circulation in this complex region. I've been working, as I said, with Mike, other collaborators at the Institute of Ocean Sciences, other scientists in DFO, as well as the industry — in particular, Stolt Sea Farm and now Marine Harvest. That continues to this day.

R. Beamish: As of November 30 I have worked for the Department of Fisheries and Oceans for 35 years and probably spent about ten years prior to that as a fisheries biologist — so maybe 45 years of experience as a fisheries biologist.

I've worked in the North Atlantic and the South Atlantic and the Pacific and in fresh water. I've published somewhere around 300 papers, about half of them in reviewed literature. I received the Order of Canada and the Order of British Columbia. I'm a fellow of the Royal Society of Canada. I was made an honorary staff member of a Russian institute called TINRO in Vladivostok.

I'm also an editor for *Transactions of the American Fisheries Society*. The American Fisheries Society is the largest fisheries society in the world — 7,000 members in 70 countries. They publish several journals. *Transactions* is their major journal, and I've been an editor there for about a year.

S. Jones: As I mentioned, I'm a research scientist in the marine ecosystems and aquaculture division at the Pacific Biological Station, where I've been employed for a little over six years. I have a BSc in marine biology and master's and PhD degrees in zoology, with specializations in parasitology. I also have post-doctoral research experience in fish immunology from the agricultural Wageningen University in the Netherlands.

Before coming to Nanaimo, I worked in the fish vaccine industry for eight years, where I was a senior scientist. For the last 23 years I've researched host-parasite interactions in fish, with an aim of understanding how fish respond to infection. Primarily, I've done this through the use of laboratory experimentation.

In this area I've published over 50 articles in peer-reviewed scientific journals. I've also published several technical reports and presented over 60 seminars and international meetings.

I'm actively involved in the peer review process, and since 2003 I've reviewed over 50 articles on behalf of 17 international scientific journals. My research is multidisciplinary and involves partners and collaborators in Canada and around the world. I've been involved in sea lice research since 2003.

M. Krkošek: I'm in my fourth year of my PhD at the Centre for Mathematical Biology at the University of Alberta. I have bachelor of science degrees in marine biology and mathematics and statistics.

For the last four years I've been studying sea lice interactions between wild and farmed salmon in the Broughton Archipelago. This has been a very intensive and highly collaborative research program that involves a lot of field sampling, experimentation and then mathematical modelling and statistics to tie together the data.

I've published three papers on the spread of sea lice from farmed salmon to wild salmon, a couple of which have received considerable public and scientific attention.

R. Routledge: I have a BSc in mathematics, an MSc in statistics and a PhD in statistical ecology. I have been at Simon Fraser University for 26 years. I'm currently professor and chair of the department of statistics and actuarial science. I'm an associate member of the de-

partment of biological science, and I'm a member of the Centre for Coastal Studies.

Formerly I was director of the environmental science program at the university. I was a member of the Fraser River Sockeye Public Review Board back in the mid-'90s, and I was a founding member of the Pacific Fisheries Resource Conservation Council, serving with Dick Beamish as an ex officio member from 1998 to 2001.

I'm active in research on sea lice in the Broughton, working with Alex Morton and somewhat with Marty. I do work on Rivers Inlet sockeye salmon. I hope to show you a bit about that today. I've been working on fire history in the South Okanagan Valley.

I've received no income to date for research directed at this project. I certainly have no personal income coming from it. My only interest is in trying to develop decent science.

[1025]

I became involved in order to help out Alex Morton here, who I felt was being pretty badly attacked by a campaign of doubt. I was so impressed by her ingenuity and integrity that I have continued to work with her for some time now. I've been offering to help. I often offer it to people who are doing the science. As a professional statistician, I provide advice on experimental design and statistical analysis.

Ron, I have a little quote for you. Ron was teasing me last time that I was a statistician and quoted Disraeli, or whoever it was, saying that there were "lies, damn lies and statisticians." I have one about truth here, Ron. "Truth I have no trouble with. It's the facts that get all screwed up." That comes from Farley Mowat.

R. Cantelon (Deputy Chair): Touché.

A. Morton: I am a whale researcher. I've been in the Broughton Archipelago for 22 years. I selected that area because it had whales and wild salmon. It was protected waters, so I could work there year-round.

When the fish farms first showed up in 1987, I thought they were a good idea. I got a job working with Stolt on a farm for a while. Then I became concerned about impacts that were occurring both on the whales and the local salmon. So I went to the Department of Fisheries and Oceans and to the province with my concerns. I then became concerned about the response I was getting from DFO and the province, so I went to other scientists to help me study this.

I went to Norway, and eventually my association with Rick…. As I began publishing, I realized this needed more science, so I opened my doors to Marty Krkošek and eventually to many other young scientists, some of whom are here. I've sold my home, and now it's a field station. I'm the director of field station Echo Bay.

I believe truly that we can have fish farming and wild salmon on this coast and that it would be better for this coast if we had both, because diversity is nature's law of survival.

I'm independent. I don't work for government, I don't work for a university, and I really appreciate you inviting me here today.

R. Austin (Chair): Thank you. What I am going to do now is move over to the first question that all the scientists were given in advance. Then what we'll do is go through the panel again and have your response to that first question so that members here on the committee can hear everybody's response. Then I'll open it up to questions.

The first question relates to sea lice infection. What we'd like to know…. The question that was posed is: what is the impact of sea lice on individual juvenile pink and chum salmon, and do sea lice infections affect the growth rates or survival rates of juvenile pink and chum salmon?

K. Brooks: This is not an area of my expertise. I have two doctorates, the first in physics, the second in marine biology from the University of Washington. In that, I studied the epizootiology of hemic neoplasia in marine mussels. So I have a familiarity with how diseases are transmitted in marine environments and how they affect populations of marine organisms, but I have not studied either of these questions in detail and will principally defer to Dario and Simon and others — particularly to Simon, who has.

I will say this. According to Parker's work, under normal conditions 55 percent to 77 percent of pink salmon fry die during their first 40 days of residence at sea. In 2001 we had somewhere around eight billion or ten billion pink salmon fry emerge from the gravel in the Broughton Archipelago. That very likely significantly exceeded the carrying capacity of the archipelago. The Broughton is not a particularly rich environment when it comes to the water column.

[1030]

In 1996 first nations expressed an interest in raising mussels, and at the time Stolt Sea Farm undertook a study, which I did for them, to assess the growth rates of mussels in the Broughton Archipelago. We put out cohorts of mussels and watched their survival and growth over a period of two years.

What we found was that they survived fine, but they didn't grow well at all. The reason they didn't grow is that there's not a lot of phytoplankton in the Broughton Archipelago. That means that the archipelago has a very finite carrying capacity, and when you overtax that carrying capacity with huge numbers of fry, which occurred in 2001, it's very likely that the system is going to crash.

I think that's very likely what happened, and it's very likely also that sea lice, being a typical parasite, attack those members of a population which are in some way compromised. In other words, they're already not performing well. Opportunistic parasites like

sea lice will attack those compromised individuals preferentially. Under those circumstances, it's very likely that sea lice, whatever their source in the archipelago, could have a significant effect on, particularly, that susceptible portion of the pink salmon population.

These are factors that I bring up at this point because I haven't heard them discussed before, and I haven't really heard this debate framed in an ecosystem way that considers what we know generally about epizootics in animals, epizootics in marine organisms and what we know generally about the archipelago.

I brought, to leave with you, a copy of a document that I wrote for Dr. Fraser's Pacific Salmon Forum called "SPG 5," which discusses some of the hypotheses that could explain what we have seen in the Broughton Archipelago. I will leave this with you, and you can peruse it at your leisure.

R. Austin (Chair): Thank you very much, Ken.

D. Stucchi: I'm going to defer on this question. This is really not an area of my expertise. This is a biological question. I'm a physical oceanographer. I'll leave it to others who are more qualified to respond to this question.

R. Beamish: Well, I'll answer the question as best I can. The research that we do…. "We" relates to the people in what I call our group of scientists, and there's about half a dozen people there. That's who "we" refers to when I use the term.

We've been looking at two components that are related to this question. The first one, of course, relates to marine survival. I understand that Dr. Riddell has already made a presentation to you, so you're familiar with pink salmon dynamics.

We started our work in 2003. I know that you probably know some of this, but let me just review it briefly. In 2003 and 2004 the marine survival of pink salmon was quite good. In 2004 and 2005 I think it's fair to say that the marine survival was average — meaning that if you look around the Pacific and look at the expectations for both odd and even lines of pink salmon, you would expect somewhere around 2 or 3 percent on average.

I don't know if you know, but pink salmon are the most abundant of the salmon in the Pacific, and they represent 50 percent of the total catch in the Pacific. So there is a lot of information about pink salmon, particularly in Russia.

In 2004-2005 we got average. But in 2005 and 2006, as you've heard, the marine survival for pink salmon in the Broughton area is poor. Again, I believe that Dr. Riddell explained that pink salmon coast-wide, into the Gulf of Alaska, have synchronously had very poor survival in 2006.

[1035]

We think that the explanation for that poor survival relates to very poor feeding conditions in the Gulf of Alaska. At our recent meeting just a month or so ago of the North Pacific Anadromous Fish Commission, Japanese scientists presented some information showing that they had done some work in the Gulf of Alaska in 2005 and 2006, and they had measured lipid levels in pink and chum salmon and compared those with the lipid levels on the Asian side. They did find that there were very low lipid levels, so there was something going on in terms of reduced food abundance.

The second project that we have is looking at when the year class — or, in salmon, brood year strength — is determined. We do scale analysis. Scales grow by forming circulae, and we use that circulae spacing as an indication of growth. Without getting into the details, what we have found was that in the periods in the 2003-2004 line — for the pink salmon that entered the ocean in 2003 and came back in 2004 — there really was no indication that size was related to mortality or survival.

However, in 2005-2006 there's a very clear relationship indicating that the mortality…. Now, we have to say it occurred after June, when our samples were obtained. But it's probable that the mortality was in the winter, as I just said. So it looks like the poor survival that we've observed coast-wide this year is related to what happened in the winter.

As I said, we have done this scale analysis for the so-called Broughton pink, and we actually presented a short paper on this at the North Pacific Anadromous Fish Commission meeting a month or so ago.

S. Jones: The context to understand the impact of sea lice on the salmon, I think, needs to be put before the committee. The context scientifically is that there's a vast body of knowledge that we have, in terms of understanding the impact of sea lice on individual fish, that comes from the European literature. Most of what we know is based on interactions between the salmon louse and Atlantic salmon or the sea-run sea trout, a related species, that occur in the North Atlantic Ocean.

We're focused here on impacts on Pacific salmon species, about which we know very little. In fact, there's virtually no information on interactions between sea lice and juvenile pink and chum salmon, which is the focus of our attention here. I'll focus my discussion on *Lepeophtheirus salmonis*, the salmon louse because, of the two species that we're interested in, this is probably the species of sea louse that we know more about from the European literature and probably presents a greater risk in general.

It was in the early 1970s that an individual by the name of Snieszko formulated a concept that disease was related not only to the presence of the pathogen — a bacteria, virus or parasite — but also to factors that are intrinsic within the host — the fish, in this case. Also, the environment plays a role in the development of disease, so disease is not simply the presence of a parasite. It also involves a susceptible host animal and a set of environmental conditions that contribute to that disease process.

What this means is that in the case of sea lice we're not interested simply in counting parasites and making inferences about impact. From that perspective, the number and developmental stage of sea lice is important as a contributing factor, but as important are those processes that relate to susceptibility in the fish host.

What is the species of fish? Not all species of fish are equally susceptible. I showed an example of that to the committee last week with regard to IHN bars. We know that the age of the fish is important. We know its genetic stock, so different stocks of pink salmon perhaps need to be explored. These may not necessarily have the same susceptibility. We need to know about the genetic history of the fish and its nutritional status.

[1040]

There are a lot of processes going on within the fish host that could contribute to whether or not a sea louse infection will actually have an impact or to the extent of that impact. Because fish are cold-blooded — they're ectothermic — their bodies respond to the environment around them.

Temperature, for example, plays an important role in the metabolism of fish, and how the fish is able to divert energy towards a defence response is dependent on environmental conditions. We recognize the importance of all of these factors in trying to understand how a fish will react in the face of something like a sea lice infection.

We are constrained by our lack of knowledge regarding pink salmon and its relationship with sea lice, as I mentioned right off the bat. One of the ways in which we can start to understand the importance of individual factors in this interaction is in the use of controlled laboratory studies where you take healthy fish, expose them to a parasite, for example, and look at the response.

You go through a step-by-step process that allows you to investigate individual responses, and you slowly build up a sense of which are important and which are perhaps less important with regard to the potential impact. It is important to speak of potential impact rather than impact because of the involvement of these other factors.

In our laboratory studies, which we've conducted over the last two years — we've conducted over 15 individual experiments — we've found consistently that pink salmon and chum salmon juveniles respond very differently to exposure to the salmon louse. We find that pink salmon respond rapidly, and this rapid response leads to a very early rejection of the sea lice.

In contrast, chum salmon respond slowly. The parasite has a chance to develop further on the chum salmon before it's cast off. But this development leads to measurable impacts, physiological as well as growth impacts, on the chum salmon, which we see consistently but which we don't see on the pink salmon.

What this tells us, then, is that it's another example of how two species are behaving very differently in the presence of a salmon louse. The fact that we've done these experiments and have made certain observations does not mean that we've completed our studies. There is still a lot to learn. We don't know, for example, whether there is a difference in the responses of the fish according to size. We've not yet looked at very small fish — the one-gram animals. The concern with one-gram animals is that these small pink salmon are scaleless, and the concern is that without scales perhaps these animals have an enhanced susceptibility.

We do know, though, that when we look at the defence response at the gill, part of the animal which is not scaled, we see a very aggressive response in the gill of pink salmon despite the absence of scales. We believe that this type of innate response is probably age-independent.

M. Krkošek: I've done some direct experiments in the field assessing exactly this question, where we've gone out and collected juvenile pink and chum salmon, brought them back to a floating lab and reared them on commercial fish feed. These are fish that were naturally infected with sea lice. We gathered them from the field during the course of an epizootic.

We reared these fish and monitored their survival. The general pattern that emerges…. We're talking about juvenile pink and chum salmon here that are about one gram. The survival of fish….

Let me just back up one moment. When we're talking about sea lice, I'm going to be talking about the motile stage. Once sea lice infect a fish, they go through a developmental sequence. There's copepodid, chalimus and then motile lice.

For the motile lice, which are large and pathogenic, the impact on juvenile pink salmon was as follows. Juvenile pink salmon with one motile louse had a survival of about 45 percent. For two motile lice, the survival was about 30 percent. And for more than two motile lice, the survival was zero. I believe that similar patterns hold for chum salmon as well.

[1045]

R. Routledge: I have a PowerPoint presentation to go through, if you don't mind. I want to talk about a holding study that we conducted. You can see some blue barrels in the water there. Those are flow-through holding facilities. These are some fish swimming in one of the barrels here. We collected fish, sorted them by lice load and put them into a number of barrels. There are some with some lice on swimming around, and there is a loner all by himself out there. He's probably going to die within a day.

We put these fish into several sets of barrels with different lice loads in each barrel and each set. Following proper statistical procedures, we shuffled them around. We did three series here.

The results from series 1. These were very small fish, probably half a gram, with very low lice loads — one or two at most at the earliest stages of lice. You can pick up on the pink salmon a significant increase in

mortality, even from zero to one of these very immature lice. Not so on the chum.

Series 2 — about one gram coming in. You can see the lice loads, going along the horizontal axis there, from zero up to five. These are all the early-stage lice. You can see an enormous increase in mortality for pink salmon, from zero up to 100 percent.

Series 3. Fish were getting bigger, and water was getting warmer. It was getting less saline. We found bigger lice loads. We only did it on pink salmon. You can see that the mortality rose from under 20 percent to over 80 percent.

Have a look at the yellow columns there, the percent of lice retained. Lots of lice were shed, particularly when the water got fresher — not surprising — and particularly in the early ones where the really immature copepodid lice were on there.

Look at the middle yellow column for percent with motile lice on the dead fish. Lots of dead fish had motile lice. Look at the surviving fish on the right-hand column for percent with motile lice. Hardly any did, confirming Marty's comments that motile lice are particularly lethal.

Simon, I believe, has found not such significant evidence. He just reported on it. It could be that lice attack only weaker fish, but they can attach themselves to big adult fish that are swimming fast. I find that a little hard to believe. Our results are also consistent with European ones, extrapolating back to the smaller Pacific salmon. A plausible explanation, as I think perhaps Simon alluded to, is that he's using larger fish and we're using really small ones here. There are the sizes again.

With respect to evidence, the presence of a single copepodid or chalimus louse can increase short-term mortality. Louse survival to motile status seems critical. We also have partial evidence of a very short fish life span after one louse reaches motile stage. I didn't show you the evidence for that. Also not shown is that we have evidence that you can't infer short-term survival from Fulton's conditioning factor. That's it.

A. Morton: The question is: what is the impact of sea lice on individual juvenile pink and chum salmon? Evaluating impacts on fish health has a history of becoming political. For example, the natural resource damage assessment team in Alaska reported decreases in body condition for pink salmon exposed to an oil spill. But researchers working for Exxon did not find decreases in body condition looking at the same cohort of pink salmon. This is in a published scientific paper, Rice et al., 2001.

[1050]

Similarly, Morton et al., 2005, which is the study Rick just described to you, found decreases in body condition in juvenile salmon infested with sea lice, while DFO did not. How is this possible?

First, by observing wild salmon already infected by sea lice, we learn that at first, infected salmon fry feed voraciously. I was watching them in those barrels that Rick showed you. For a time, a fish is able to eat enough not to lose weight, but as the sea lice grow, the fish's body pinches down around the dark lice wounds. You can see that without scales, these lice are eating right into the flesh of the fish.

In the absence of predators — in other words, in the barrels — fish shrivel down to a skeletal form. This is a visible and measurable decline of body condition. However, you rarely catch a fish like this because they're eaten long before by juvenile salmon predators. Those of us who've gone looking for loners, which is what we call these fish because when they get to this condition they no longer know how to swim with their school…. They swim on the surface and become highly vulnerable to kingfishers and mergansers and to other fish.

Second, Simon Jones studied a different age group of juvenile salmon. His fish were many times larger. I went and visited his experiment and saw that the fish were much, much bigger. It was June or July when I went there, much later in the season. His fish had protective scales, like a suit of armour, and he lethally sampled his fish before they died of sea lice. He was sampling them at regular intervals, and in the time period it took my fish to die, Simon had already collected all of his.

Third, this is simply the difference between working for Exxon and not. DFO is tasked to promote salmon farms, and I am under no such constraint.

I don't make this comment lightly. I've been watching this. Dick Beamish actually began working in the Broughton Archipelago in 2001. Since that time our results have been so different that it's been very alarming to me. So I don't say this lightly.

R. Austin (Chair): Thank you very much. I'm going to open the floor to questions from members.

S. Simpson: I want to thank all of you for being here. It's very valuable, the contribution you'll all be making to this process.

I have a couple of questions. The first one is for Ken Brooks. Mr. Brooks, you talked about the finite carrying capacity of the Broughton through limited levels of phytoplankton, I believe you said.

The question I have is…. We know that the Broughton is the area where there's the heaviest concentration of aquaculture, of fish farms. Does that create a complication as well? You talked about the challenge with chum and with pinks and the large numbers, and whether that reduces their ability to survive this limited carrying capacity. Does that get compounded by having this large number of fish farms in there, in general terms and in terms of potential impacts around lice?

K. Brooks: Two points. Back in the '70s the Russians on Sakhalin Island were enhancing the chum fishery there. They slowly increased the number of releases, and what they found was that they very quickly got to a point where the returns actually started diminishing. The conclusion they reached was that they were exceeding the carrying capacity of some

critical part of the environment through which these chum salmon passed.

In the Broughton Archipelago I wouldn't say there is a high density of salmon farms, but there are a large number of salmon farms. That's agreed. There's no evidence that I'm aware of that caged salmon consume the same types of food that pink or chum salmon would be consuming. Ed Black with DFO did some studies looking at the stomach contents and the foraging habits of Atlantic salmon and culture, and found that there was no evidence that they were consuming significant quantities of any kind of wild fry.

[1055]

For those of you who are fly fishermen, you know that one of the rules is that you match the hatch. Farm salmon are used to eating salmon pellets. That's what they look for, and that's what they consume. All of the evidence that I have seen suggests that they ignore essentially all other food sources in preference for the salmon pellets. That's one of the reasons that in escaped Atlantic salmon — I forget the exact number — something like 97 percent of their stomachs are empty even after several weeks at sea.

To answer your question directly: no, I don't think salmon farms exacerbate the limited carrying capacity of a water like the Broughton Archipelago. I don't know whether or not the sea lice released by farmed salmon contribute significantly to the background levels of sea lice in the archipelago, because we don't know what those background levels of lice are in the archipelago.

Three years ago we were told that there were no other sources of *Lepeophtheirus*, at least in the archipelago, other than the cultured salmon. Since then we have found that there is a significant source in the three-spine stickleback.

I'll also say briefly that in 1998 Costello hypothesized, based on his work in Killary Harbour in Ireland, that there was likely a resting stage of some kind for sea lice that enabled them to overwinter and to be available to infect out-migrating smolts. Until the work done here in B.C. identifying three-spine sticklebacks as a potentially significant source of lice, Costello's hypothesis had never been tested.

I think these are probably the first insights we're getting into how sea lice have evolved life histories that enable them to survive from the time when the adults return to the archipelago — carrying, as Dick Beamish has shown, huge numbers of sea lice back into these inshore waters — through the winter to infect new cohorts of salmon that are out-migrating in the spring.

S. Simpson: A question for Mr. Krkošek. It's kind of a combined question. The first is…. When you talked about the percentages around mortality, I just want to confirm that in almost all instances these were on one-gram or very, very small juveniles. That was the focus of your science?

M. Krkošek: Yes, that's correct.

S. Simpson: Could you talk a little bit about…. In your research, you spoke a lot about the preponderance of sea lice and the source being the farms. Mr. Brooks has talked about the three-spine stickleback, which I admit to not knowing as much about as I should.

My question to you would be: do you think that that's a legitimate position? How do you respond to the position that there is, in fact, a preponderance of lice potentially caused by that species of fish?

M. Krkošek: I've seen data showing that there are high abundances of *Lepeophtheirus salmonis* on stickleback. Almost all of those lice are in the juvenile stages, so these are the chalimus-stage lice. This is before they become motile and before they become reproductive. There are very few motile-stage lice observed on these fish, and there has not yet been, to my knowledge, any observation of a gravid egg-bearing louse on a stickleback.

What this suggests is that the lice cannot complete their life cycle on this species of host, which means that this host can function in two different ways. It can function as a source of lice, or it can function as a sink of lice. If the parasite cannot complete its life cycle on this host, then this fish is actually doing all the other salmon a favour by allowing lice to infect them. And then the lice are dying. So it's an open question yet as to whether or not sticklebacks are a source or a sink for lice, but on the observations of the data that's available, the data certainly strongly suggests that sticklebacks would be a sink for lice.

There's a second answer to this question. The results that we have showing that the sea lice are spreading from farmed salmon to wild salmon depend on distinct spatial profiles in the abundances of sea lice on migrating juvenile salmon as they go past the farms. You see lots of young lice near the farms, and then you see those cohorts of lice maturing as the juvenile fish are migrating and transporting the lice out to sea.

[1100]

In order to produce patterns like that in the data, you need a host that is stationary in one location at high density and with lots of parasites on it. I think it's unreasonable to assume that a wild fish would aggregate for a month at a time at exactly the locations of the salmon farms and nowhere else in the Broughton Archipelago, so that hypothesis is, I would say, very unlikely.

S. Simpson: One last question for Mr Jones, and it relates to this issue of fish size. Both Mr. Krkošek and Ms. Morton have suggested in their comments that the size of the juvenile is a critical part of the analysis and the hypothesis here and that they dealt with fish that were in the one-gram size, or around that area. I believe that in your comments you said that your experimentation is proceeding to there but you haven't quite done that yet. Maybe correct me if I'm wrong on that.

The question I have for you is: is that a legitimate hypothesis — to say that if we're talking about one-gram fish size, they may be impacted in a different and more negative way than the fish that you've been doing most of your work on to date?

S. Jones: You're quite right. That is a legitimate statement to make. The fact is that we know very little about how pink salmon respond to sea lice. The work that we're all doing now is the first series of experiments to explore these questions. We have come up with some answers, but we recognize that there are many, many more questions that still need to be answered. The size question is one of these uncertainties.

The fish sizes that I've studied in my experiments range from approximately three grams up to in excess of 25 grams, and in some of the work we're doing now, the fish are even larger. We see consistently the same pattern among this range of sizes, but the possibility exists that there is a threshold below the four-gram size where the fish develop an acute susceptibility.

Perhaps it's related to the absence of scales. We're collecting data now on how soon pink and chum salmon develop scales by sampling them and looking very carefully at the skin during the early growth of this salmon. Experiments that we propose to be conducting will compare susceptibility where we know exactly what the stage of scale development is.

Having said that, when we look at how fish are responding in the experiments that we have done — these are pink and chum salmon — some of the sea lice attach to the gill. The gill is a very delicate structure that, as you may be aware, the fish uses to breathe in the water. There are no scales on the gill. The pink salmon mounts a very aggressive tissue response in the gill, which we believe is part of that response that allows the fish to cast off the parasite quite quickly. It's the same response that it mounts on the skin.

Simply the absence of scales does not necessarily mean an absence of a capacity to respond. We haven't looked at the one-gram fish yet. We will do that. But our data does suggest that the absence of scales in the gill — not on the skin — does not reduce the capacity of the animal to respond. This innate ability of a species such as the pink salmon to respond to sea lice typically is not as strongly age-associated as some other types of responses. We're not quite sure yet how the small pink salmon will respond. That is a study that we still need to address.

R. Cantelon (Deputy Chair): You mentioned, to Dr. Jones…. Well, let me first….

To Dr. Morton, if I may. The inference we were to make, I gather, is that DFO's studies are different because they're in the business of promoting salmon, which suggests a bias because of their role in developing fisheries industries. I guess it's fair to ask you, then: who funds your research?

A. Morton: That is a fair question. I just want to say that the opinion I gave there — the difference between what Exxon and what other researchers found — wasn't my finding. That was in the published literature. I found it interesting because it was so similar to the conflict we see here. That's one of the things you do in science. You look for examples throughout the literature to compare your own work to. So I went to that, and it was very clear. There are many other examples that I didn't include.

[1105]

Initially, no one funded me, because it was such an unpopular subject that I was working on. Eventually, the coalition for aquaculture reform said that I had to take money or they were going to kick me out. So now I do get paid by the coalition for aquaculture reform, which is looking for solutions to the debate we're talking about here. I am hoping we will reach those solutions.

It's only fair that everyone be given the opportunity, of course, to buy groceries and put their children through school. It is a very fair question, and I wish that I never had to take money from another group, but it's simply a fact. However, it's not a corporate sponsor. Really, I mean no offence to the scientists who are under the constraints from Fisheries and Oceans Canada, but they are tasked to promote salmon aquaculture. I think it's an unfair conflict that these men and women are being put into in this case and in other cases.

R. Cantelon (Deputy Chair): Is the coalition your sole source of funding, then?

A. Morton: Oh, yeah. You can go to their website and figure all those things out.

R. Cantelon (Deputy Chair): If I may, I have a question for Dr. Routledge. I have to say that I did take statistics at a very elementary level in university. I want to clarify that. I only have the highest regard for anybody who can understand these things, and Dr. Krkošek, the same compliment applies. I won't ask you to explain formulas either.

We have quite a wide range of fatality — from 9 percent to 95 percent — and this is a bit perplexing to the non-scientists like me. I presume it's related. Either of you who wish to answer can do it. We know that 95 would be bad, but we also understand that the survival rate naturally is not good news for the pink salmon. It's anywhere, as we heard today, from 55-percent to 70-percent fatality. One question would be whether the result you see is incremental or wrapped into that.

When does the 95 percent apply, which probably is unacceptable, and when does the 9 percent apply, which may be acceptable considering the survival rates? Which is it?

R. Routledge: Well, first of all, lots of things kill fish, especially young juvenile pink and chum salmon that come out to the sea so small. I've been doing a lot of work up in Rivers Inlet, and those fish very often have a very low survival rate.

If you do something like expose fish to a new source of mortality…. I just disagree strongly. There is no evidence that these lice were around before. You expose them to a new source of mortality like that, and you take away their chance for survival.

Our little holding study suggested that at the levels of lice infestation we've seen in the Broughton in some recent years, mortality will be very high. That holding

study showed that it was high when you keep them in a barrel. Alex was sleeping on her dock at night to make sure a marauding otter didn't come and get them. They were protected from predators. You expose them to a predator risk, and the mortality from the lice will probably be worse.

R. Cantelon (Deputy Chair): To my question: which is the operating factor? Is it 95 percent where it's close to the farms? And how far away? When is it 9 percent? Because 9 percent on these survival rates might not be a huge factor — I'm not a scientist — but 95 probably would be.

R. Routledge: Well, 95 would be enormous.

R. Cantelon (Deputy Chair): I know 95 is bad. You gave that answer before. But which is it? Does 95 affect most of the salmon, or does 95 only affect a small portion of the salmon in the Broughton?

R. Routledge: If the lice loads are sufficiently high, I would say that figure from our second series of those experiments demonstrates that it would be very high — 100 percent if the lice are frequent enough.

M. Krkošek: You asked about what the more general case is. Is it 95-percent mortality or 9-percent mortality, and what is causing what range in estimates? The range depends on two factors. This range spans several studies looking at different migration routes at different times in the migration season and in different years. The mortality depends first on how many salmon farms are along those migration routes. The higher mortality estimates are from the migration routes with the greater number of salmon farms. Those are also the ones where there were more lice.

Then, there's also a seasonal effect. The mortality increases as the season progresses, and that's because there's a delay due to the development of lice. Early in the season most of the lice population is in more juvenile stages. They're younger lice, and they're not as pathogenic. It's at the end of the season where you get the lice population maturing to its final motile stages. This is when they're the most pathogenic, and that's when you get the highest mortality estimates.

[1110]

At the same time, these lice become of reproductive age, and you can get secondary generations of lice occurring. The total abundance of lice can rise very rapidly towards the end of these field seasons. So it depends on several factors.

R. Cantelon (Deputy Chair): Could you put a time frame on that season for me too?

M. Krkošek: In the Broughton Archipelago it would be generally between early April and the end of May.

S. Fraser: Thank you all for coming today and helping us with this issue. Sea lice, of course, have become not the only issue but one of the main issues that the public has raised concerns about.

Dr. Beamish, you mentioned that you started work in 2003 on the issue — "you" as in the collective you that you referred to, I assume. Dr. Morton, I don't know how long you've been working on studying sea lice.

A. Morton: Since 2001.

S. Fraser: Since 2001. We've heard deputations here that indicated that the link to potential problems with sea lice and wild has certainly been made in other jurisdictions, other regions, in the world. Norway and the North Atlantic have been cited already.

What's the time frame for that link being made internationally? Has there been work done internationally prior to this work being done here? I don't know who to ask it to.

A. Morton: I can answer that.

S. Fraser: Dr. Morton.

A. Morton: First of all, I'm not a doctor, but it's nice of you to think so.

S. Fraser: Oh, sorry. I was giving everyone the benefit of the doubt here.

A. Morton: In reviewing the literature in Norway…. Those were the experts. When I first ran into these sea lice, there was no work being done in British Columbia, so there was no one to go to on it. They all said that prior to salmon farming, sea lice were not seen on juvenile salmon.

There's a review work by Pike and Wadsworth, I believe it is, published in 1999, which is an excellent piece. It reviews everything that was known to that point. In it, they made it very clear that nothing was known about sea lice on juvenile Atlantic salmon or sea trout prior to that. They just didn't see them.

In reviewing what the fate of pink salmon was when they first entered the marine water, I went to one of the top experts on pink salmon, Dr. Bill Heard from Alaska. I just called him and said: "Dr. Heard, have you ever heard of *Lepeophtheirus salmonis* sea lice on juvenile pink salmon?" He said: "No, absolutely not. You go out there and collect as many as you can."

People did a lot of work on juvenile salmon. There is some really seminal work that preceded 2001 by decades. Those men handled a lot of pink salmon, and they did notice an infection with the other type of sea louse, *Caligus*.

Lepeophtheirus is bigger than *Caligus*, so had there been an infection, had this *Lepeophtheirus* been part of juvenile pink salmon biology, somebody would have seen it. It would have been very obvious. There's no record in the Pacific because I don't think it occurred, and there was no record of this type of infection in the Atlantic because it hadn't occurred.

S. Fraser: I have a follow-up, but there are other people who want to speak, I think.

S. Jones: In the mid-1960s Bob Parker — who you've heard referred to already as the individual who documented the early high mortality of juvenile pink salmon in the nearshore environment of British Columbia — actually described for the first time a species of sea lice on juvenile pink salmon in that coastal environment. This was *Caligus* not *Lepeophtheirus*, but it did provide insight into the ecology of host and parasite interactions and, for the first time, provided evidence that juvenile pink salmon are exposed to at least that species of sea louse on the coast.

Quite rightly, we've not seen evidence earlier than maybe five or six years ago of *Lepeophtheirus salmonis* on juvenile pink and chum salmon in the nearshore environment. But there was very little effort to actually look for these lice.

We've surveyed in the Broughton Archipelago. We're aware of evidence from other parts of the coast that *Lepeophtheirus salmonis*, the salmon louse, is a common parasite of juvenile salmon in the Broughton Archipelago but much less so in other areas of the coast.

The prevalence of the proportion of individual fish — juvenile pink and chum salmon — exposed to *Lepeophtheirus* in other parts of the coast tends to be considerably lower than in the Broughton Archipelago. This is whether there is salmon farming present or not. There are areas other than the Broughton where salmon aquaculture does take place and where the natural occurrence of sea lice is quite low.

[1115]

In our studies in the Broughton Archipelago we do find *Lepeophtheirus*. The vast majority of the *Lepeophtheirus* we find are the very small, early developmental stages of this parasite. When you're examining these fish for this stage of parasite, you need to have a magnifying glass, or ideally, you need to have the fish back in the lab with a microscope.

These are very small, early stages, and it's quite possible that individuals who have not seen lice on juvenile pink and chum salmon were not able to see them because they didn't examine the fish properly. They were not using the correct magnification. We really don't know, but I suspect that the absence of evidence of the parasite is certainly not evidence of its absence in that part of the coast.

S. Fraser: Could I just ask a follow-up on that, Mr. Jones, as far as what you just said? Let me get it straight. You said that the Broughton is maybe not unique, but it has a higher incidence of lice, whether or not the salmon farms were involved in the Broughton. Is that what you said?

S. Jones: What I'd said was that we've looked at juvenile pink and chum salmon in the Broughton where, of course, there are salmon farms. But we've also got evidence from other studies on the coast of British Columbia where there are or where there are not salmon farms. In all of these cases we find levels of lice to be much lower than in the Broughton Archipelago.

S. Fraser: But DFO hadn't done any work before 2003 on the lice in the Broughton. Then, you're saying the link isn't there between the salmon farms and the lice in the Broughton.

S. Jones: Prior to the 2002, I think, there was no systematic surveillance of juvenile salmon in the Broughton. Bob Parker's work was up in the central coast, and it was not in the Broughton.

S. Fraser: Dr. Beamish, did you have your hand up too?

R. Beamish: Well, Dr. Jones has answered that question. The species of sea lice, of course, was *Caligus clemensi*. I don't know if you've read that paper, but it's a very interesting paper. He remarks that they detected this because they were doing some studies, I believe, on chum salmon too.

The sea lice were actually consuming portions of the fins. This is what attracted their attention, and that led to the discovery that this actually was a distinct species from what it had been identified as. It's quite important, you see, because this was the earliest recognition, in the early '60s, that sea lice were causing some harm to these very small salmon. It's quite an interesting paper.

S. Fraser: If I could just finish off. Mr. Jones, you mentioned that you're constrained — or we're constrained, I guess, collectively — by lack of knowledge and that you haven't looked at the one-gram pinks. With the recent peer-reviewed work that's being done, is that gap not being filled now, with the work that the other scientists present have been engaged in?

S. Jones: I gather their studies have included very small, one-gram pink and chum salmon. I wasn't aware of exactly what size they were, but I was aware that they were smaller than the fish we've been conducting work on ourselves.

S. Fraser: Would that be used, then, as far as the work that you do?

S. Jones: Very much. Part of the scientific approach is to conduct confirmatory studies and to repeat a set of experiments to confirm that the observations that were made, either by ourselves or by others, are consistent. This is certainly what we intend to do.

C. Trevena: I just want to take on that and something Shane was asking. It's on the size of the fish. Ms. Morton said it's like comparing apples and oranges, because it's two different sizes of fish. I would like to ask both of you, Dr. Jones, whether your team will be examining smaller fish and likewise, Ms. Morton, whether you're going to be examining larger fish so that it's not so much the apples and oranges.

S. Jones: The apple-and-orange component arises on a number of different levels. Of course, as I mentioned earlier on, we will be looking at smaller fish, perhaps one-gram but certainly in that range. What we would like to explore is the relationship between the presence and absence of scales.

[1120]

The scale development occurs at approximately the size of one gram in pink salmon. We'd like to look at how, in a laboratory environment, the fish respond to that infection before, during and after scales are formed.

The other way in which these studies differ is that the laboratory study tries to control as much as possible the various factors that contribute to the ability of the salmon to respond. In our studies we don't see mortality, even in fish that are as small as four grams.

In fact, we have so infrequently seen mortality that we feel there is a very clear difference between the pink and chum salmon that we study and the Atlantic salmon that is described in the literature, where mortality is a very reproducible consequence of being exposed to sea lice. All of the European work is based on laboratory studies as well. They have the same types of controls built into their system. In our case, we don't see mortality.

The other way in which they are apples and oranges is not only the size but the fact that we have a control system in which we start with healthy fish. We impose sea lice on those fish, and we're controlling for background noise, if you like — other possible contributors to mortality.

When you're sampling fish from nature that already have a sea lice infection, you really have no way of knowing what else is going on. It's easy to see that you have sea lice, but are there other issues? Are there differences between fish that have sea lice and those that don't, in terms of their nutritional status or their genetics? Are they from different stocks or the same stock? All of these are important in terms of contributing to mortality, so I think the apples-and-oranges thing is a valid point. But it's bigger than just size. It deals with issues of the type of fish that you're using as well.

A. Morton: No, I don't plan to study the larger fish because there's a great deal of literature already on the existence of sea lice on larger salmon. Once the fish are larger, they're considered a benign parasite.

One of the most unusual things about Dr. Jones's work, which I couldn't understand, is that when I went to visit his fish, they were being held in the complete dark. I was there during the day. It was about 4 o'clock during the day, and I couldn't understand why the fish would be in the dark. Even if you were trying to simulate the daylight period in March or April, it's still light at 4 o'clock in the afternoon. So there were a lot of differences between what he was doing and…. It was valid, in what he was doing, but I don't think it represented the wild situation.

Furthermore, I would hope somebody would ask him where the DFO has studied wild fish among fish farms and not found sea lice. I'd be very interested to know where that was.

C. Trevena: I actually have one follow-up — okay? It's not that question. I wondered if anyone on the panel knows whether the Europeans have been studying the small fish, the one-gram-or-less fish and, if so, what they've found.

A. Morton: In the Atlantic none of the salmonid species enter sea water at that size. They spend a winter, at least, in fresh water. They're entering sea water at about 60 grams, as I understand it. Pink and chum are the only salmon in the world that enter the salt water right after hatching.

R. Routledge: It might to help to keep in mind that the Europeans, when they try to make conclusions about lethal levels of lice on fish, do it per gram of fish. Underlying that is an assumption that if you have a fish that's twice as heavy, it can tolerate twice as many lice on it. If you extrapolate their estimates back to pink and chum salmon of one gram on the coast here, one motile louse should kill them. And that's exactly what we've been observing.

K. Brooks: The point that Simon touched on that I want to emphasize is that we do bioassays in our laboratory. And government uses bioassays, which are when you challenge a test organism with a toxicant or with a parasite, if it's a disease study — very specifically, highly defined protocols for doing these types of studies.

[1125]

In every case these protocols require that you start out with healthy animals. And the protocols require that your control subjects have a certain survival, 90 percent–plus, or the study is considered invalid.

Usually those protocols dealing with fish will require that the fish be held for some period of time — a couple of weeks, three weeks — to ensure their health before they're entered into the test. If you don't do that, then you really don't know what caused the reaction — be it a loss of weight, a change in osmoregulation, an elevation of certain hormones or the death of that animal. You don't know what caused that because you don't know what underlying complications affected the health of that fish before it ever entered the test.

Your government would never accept bioassays — and these are all bioassays that are being conducted — from industry or anywhere else that did not follow these protocols. These protocols all require that you start out with healthy animals.

R. Routledge: I'd like to respond to that. The very first studies ever conducted that demonstrated adverse health impact on fish from DDT were conducted in preserving jars in a little place in East Africa. That was published in *Nature*, and that evidence eventually made it into Rachel Carson's book.

J. Yap: I want to thank you all for participating in this hearing. I know you're all very busy.

My first question is for Martin, and it has to do with the fundamental question here, I guess, which is that

sea lice tend to congregate around or close to fish farms. I guess that's the fundamental issue that we're dealing with here. My question is: was there evidence in your studies, first of all, that proved it is a fact that there's a high concentration of sea lice near or around salmon farms?

M. Krkošek: There are several studies finding spatial associations with increased sea lice abundance near salmon farms. In all the work that we've done, when we're sampling these juvenile fish as they're migrating past the salmon farms, the consistent observation is that near the locations of the salmon farms you see a high abundance of copepodid lice. This is the most juvenile stage of the parasitic lice, indicating that infection has recently occurred — within the last day or two — and also indicating a relatively nearby source of the larval lice.

J. Yap: So that same study would show that a similar location but without a farm nearby would have a different level of infection or presence of sea lice?

M. Krkošek: Yeah. The most powerful test you could do would be to do the experiment where you sample fish migrating past a salmon farm in one year, and then in the next year have that salmon farm removed or empty of fish and see if there is a response. See if the amount of copepodid lice on juvenile fish in that area disappears or declines dramatically when there are no fish in the fish farm. That's an experiment we haven't done yet, but it's an experiment that is being planned over the next couple of years.

J. Yap: That particular thesis hasn't been tested yet.

M. Krkošek: No.

J. Yap: But the stage of the life cycle for these lice that you referred to…. Would they also occur in the natural environment far away from any farms?

M. Krkošek: Yeah. One of the outcomes of the work that we've done is that when you go way up these migration routes, before these juvenile fish have passed any salmon farms, you still see some sea lice on these fish. If you go into regions that are very distant from salmon farms — say, around Prince Rupert or Bella Bella — you still see low abundances of sea lice on these fish.

[1130]

Over all these areas this background infection seems to be happening at about 5 percent. When you look at areas where there are salmon farms and look at the juvenile fish after they've passed the salmon farms, the prevalence of sea lice can rise dramatically, up to over 90 percent, and you get counts of about 30 or 40.

J. Yap: That was up to 90 percent — from 9 or 10 percent to 90 percent. Is that the…?

M. Krkošek: Before the salmon farms, around 5 percent. After the salmon farms, ranging up to…. I think the highest we've seen was about a 98-percent prevalence of sea lice.

J. Yap: At the high end. And at the low end, from…?

M. Krkošek: At the lower end would probably be somewhere around 30 percent or 40 percent.

J. Yap: I'm confused. I thought there was a range of 9 percent to 95 percent.

M. Krkošek: The range from 9 percent to 95 percent is an estimate of the mortality of the juvenile fish.

J. Yap: Okay. The mortality.

M. Krkošek: What I'm speaking to here is the percent of fish that actually have sea lice on them — so the prevalence of sea lice on these juvenile fish.

J. Yap: In your study do you make a correlation, or do you conclude that there's a causation of the mortality?

M. Krkošek: In the study we're able to estimate the magnitude and spatial extent of sea lice transmission from farmed to wild salmon. Then we have independent estimates of what the pathogenicity of these lice are to these juvenile fish. When you put these two pieces of information together, then you have an estimate of what the mortality impact is from the sea lice coming from the fish farm.

J. Yap: I'm trying to get my mind clear here. Is that a causation, or is that a correlation?

M. Krkošek: It's all correlative. The only way you could show causation would be if you directly observed a parasite leaving a farmed fish, going through the water and attaching to a wild fish and then killing that wild fish. I'm not sure if it's even possible to do that.

J. Yap: So that would be the most definitive way of proving….

M. Krkošek: That would be observing a direct causal relationship, yeah.

J. Yap: And that hasn't been done yet.

M. Krkošek: No.

J. Yap: A question for Dr. Beamish. In your presentation you talked about poor feeding conditions. You described how there was something going on in the Gulf of Alaska, and lipid levels were different. But I didn't hear — maybe I missed it — that from that discussion you have a conclusion. I'm wondering if that conclusion is that it could have been poor feeding conditions that caused the poor returns.

R. Beamish: The conclusion is exactly that. But like all conclusions in science, that's the interpretation.

What I didn't tell you was that at the North Pacific Anadromous Fish Commission meeting, which is an international organization dealing with salmon in the north Pacific, I was asked to chair a special session on what happened to pink salmon throughout their distribution in 2006. We discussed — "we" meaning in this case a number of experts from around the Pacific — looking at a variety of things that pink salmon did that were unusual. I won't get into those.

Of course, we from the North American side were interested in this maybe unique, coast-wide really poor survival. I think it's fair to say that the consensus was that we were looking at very poor growing conditions, if you want, in the Gulf of Alaska as an initial explanation for this very poor survival, coast-wide, of pink salmon in the winter of 2005-2006.

The relevance to this discussion is that the mortality would have occurred, we can only say, after June or July. But it's highly probable that the mortality or the brood year strength was really determined in the winter, then.

I can just add one more thing. After this discussion, which took about two hours, I was asked to write this all up on behalf of all the participants in that meeting, and I'm in the process of doing that, along with Dr. Riddell and some Russian scientists and an American scientist.

[1135]

G. Coons: Thank you so much for coming. If we look at the first question — what is the impact of sea lice? — I guess it comes down to another "we don't know." The research isn't there. Basically, there's no information and research on sea lice and Pacific salmon. There's no baseline data.

Specifically, I put a lot of faith — or have put a lot of faith — in DFO, the work they do and the scientists. I refer back to a fact sheet of October 2005 that basically said there is no evidence in the fish we have sampled that shows sea lice have a negative effect. There's no evidence to support the notion that migration corridors…. This does not support allegations that emptying certain salmon farms…. All of these things saying that the research is not there, that there's no baseline data.

But again, we've got DFO coming out and saying, "Things are okay," it seems. An article in the paper just recently was: "Fish Farming Necessary — DFO Scientists." I read that with great interest. Again, in there, it said DFO scientists are doing their best. Things need to be studied and explained.

Basically, I want to ask: are we…? Again, our first question — I'm not getting an answer to it. It's still a big question mark until the research, the baseline data…. It could take years and years to get there. Are we, as the Oceans Act defines, erring on the side of caution as far as development of aquaculture in British Columbia? That's a question I want to ask the panellists.

R. Routledge: Definitely not, especially if we allow fish farms to expand up the coast. We really don't have a proper handle on what's happening in the Broughton Archipelago and in many other areas where we have fish farms. I hope to have some time to show later some evidence we've gathered that there are high lice abundance levels around farms in other parts of the coast.

I also hope to have a chance to talk later about some very severe concerns I have about small coastal sockeye stocks, where if we let fish farms anywhere near them, they come out small — like two grams. If you have fish farms near there, we might lose those, and those have been identified as having local genetic adaptations at a significant level within individual lakes. That's a serious long-term loss, and that's not operating according to the precautionary principle.

A. Morton: If the Broughton Archipelago was the first place this problem had been seen, I think we'd all be a lot less certain that it's sea lice. But there was absolutely every reason to expect this to happen.

When I first found small fish covered in sea lice, I wrote to the Norwegian experts. Their first question to me was: "Do you have fish farms?" It has happened absolutely everywhere that salmon farms are put in channels that young wild salmon use. There was every expectation this would happen. The results that the three of us — Rick, Marty — and others in British Columbia have found are completely consistent with the European situation.

I think if there was a question to DFO, it would be: how is it different? Why would we try to come up with "probable," "very likely," "we know very little about…."? Why would we use all those words to apply to the situation when so much is known in Europe and to date we're finding exactly the same experience here? It would seem an area for the precautionary principle.

Nobody's saying get rid of the salmon farms, but get them away from where the fish are so young and tender. That is absolutely, across the northern hemisphere, what all the science says. There's no debate in the scientific literature. In the literature that been peer-reviewed and published, there's no debate that the farms have had this effect everywhere they go.

There was no reason to think it would be less of a problem. In fact, when researchers saw the pictures of our pinks and chums, they kept saying to me: "Your lice are so huge." I said: "No, our fish are so little. We have littler fish." The expectation was that the problem would be more severe, and it's coming to pass.

K. Brooks: I'll respond to that. First of all, in the European literature the debate continues to rage. There is no consensus.

[1140]

There are those who believe that salmon farms are a significant contributor of sea lice and that those lice are having a significant effect on Atlantic salmon and on sea trout stocks. There are others who say that no, the evidence from their studies suggests that the salmon farms are not having the effect and that the effects of

sea lice are in fact originating on wild fish. There are two opinions here. That's the first point I want to make.

The second point that I want to make is that sea lice and salmon farms are not inevitably correlated. In Washington State we have eight salmon farms. We have never treated any of those salmon farms for sea lice. Sea lice are simply not a problem. No one has documented epizootic disease in Washington State associated with juvenile salmon and sea lice.

The third point that I want to make is that the precautionary principle as stated in the Rio declaration says that where there is significant probability of irreversible — and I emphasize the word "irreversible" — and widespread effects, lack of scientific certainty should not preclude taking precautionary actions.

Salmon stocks in the Broughton Archipelago in 2004 were almost twice the returns that were seen as an average before the Glendale spawning channel was put in. They were right at a million fish. Prior to Glendale the average returns to the Broughton were around 475,000 fish. Almost 2½ times as many fish returned in 2004 as the pre-Glendale average return.

In my opinion — and DFO can address this far better — there is no imminent evidence of a collapse of Broughton stocks. The stocks appear healthy. If I'd known we were going to have PowerPoint presentations here, I would have brought you some slides of pink salmon returns to Washington State rivers, in which the pink salmon returns have fluctuated by two to three orders of magnitude over periods of years. No salmon farms anywhere near them. They had completely disappeared from some rivers for periods of up to ten years, and then suddenly they re-emerged in the rivers as a viable resource.

These stocks are highly variable. I see no evidence that stocks in the Broughton are in jeopardy of collapse. In fact, if you look at the data — I published some of the first in the first paper I wrote — pink salmon returns to the Broughton increased exponentially during the years when salmon farming was started. There was no evidence that there was an incompatibility until this 2000 collapse.

In 2000 there were 3.7 million pink salmon that returned to the Broughton Archipelago. If their average fecundity, number of eggs, is around 1,800, that means there were eight billion eggs laid in Broughton Archipelago watersheds. If you assume a 40-to-50-percent survival, that means there were four billion pink salmon fry that left the archipelago. I will repeat that it very likely significantly exceeded the carrying capacity of that archipelago.

There are no similar returns to the Broughton. In fact, if you look at the history, in most cases where the number of returns exceeded a million fish, in the next year or years following that there were significant declines in the numbers of returns.

A. Horning: Ken, you've probably answered some of my questions here. I was also going to ask…. The wild fish in 2000 was a record year. Now, in 2000 it was basically normal, yet fish farms have been around the Broughton for 20 years. So why haven't the pink salmon been wiped out? That would be the consensus if, in fact, the lice from fish farms are affecting the pink salmon. Yet you've just said that's not the case.

[1145]

My question is maybe to others here. Why haven't they been wiped out? Is the theory of them killing that devastating or not? You have answered it, but maybe Ms. Morton or somebody here may want to clue me in on that.

R. Routledge: On the east coast there's been mussel farming going on for sometime. After a couple of decades or so, I think, the mussel farmers were very unpleasantly surprised to find that tunicates started showing up on their mussel strings, not causing environmental damage outside the farms but smothering the mussels and reducing their growth rate. They knew that they were causing the problem and that they had to accept it.

The interesting thing here in terms of your question is that this took a long time for it to happen. The responses don't necessarily happen right away.

A. Horning: So the emphasis being that…. I'm reading all the time about the lice being so devastating on the wild salmon. The theory is that there'll be less and less and less, and eventually they'll be wiped out. Well, it's been 20 years and still we're having records and what have you. The theory of the lice being devastating, from fish farms to the wild salmon…. Is that a myth or is that actuality? Is there any evidence that we are eventually going to get wiped out by the sea lice?

R. Routledge: Do they have to be wiped out before people get concerned? I think not. If they're substantially reduced so that they're not at their historic levels of abundance returning to a thriving ecosystem, I would say we have a problem. I'm not prepared to make a prediction as to whether some species get wiped out or not.

A. Morton: When salmon farming started in the Broughton Archipelago, there were 125,000 fish per farm. Then in 1995 we had the moratorium. If you look at the number of farm fish created in the Broughton, the arrow goes on up. It doesn't reflect that moratorium. Since we know they got no more sites, it's clear they got more fish. It's a small community, and people talk. I know that there were up to 1.3 million farm fish per farm on some of the exact farms where we've seen sea lice problems.

It's a numbers game. The more hosts you have, the more potential you have for parasites. The more parasites you have, the more baby parasites you're going to get and the higher the infection rate.

I think what was happening was that we got spawning channels, we built those salmon runs up — we got some beautiful peak runs — and it collided with the huge number of Atlantic salmon in the pens. Then we got the crash. So 2004 is a very special year. Those fish went to sea without sea lice, so the spike in 2004 tells us that if you remove the farm fish from some areas you get more wild fish.

In 2002 the PFRCC called it an emergency, and the option 1 by the PFRCC was to remove every single salmon farm from the Broughton Archipelago. That was Dr. Riddell. They didn't take option 1; they took option 2, which was to remove some of the salmon farms and treat the rest. Other bodies have made the decision that it was an emergency. It was a very severe situation.

G. Robertson: Thank you all very much for being here. It's great to have you all in one place. At the same time, I feel like we've left a few of these points kind of hanging in the air, and it may be the challenge of the forum, not allowing debate to try and come to some more conclusive outcome.

On this issue I was most struck a few minutes ago by the contradiction between Ms. Morton and Mr. Brooks about the body of evidence from Europe and Norway and Scotland. Could you two carry that on a little? Maybe specifically the peer-reviewed science that comes from the European research on the impact of sea lice on the wild populations there.

I hear one side of it, that it's overwhelming — that there is in fact impact. Mr. Brooks stated that there are two sides to that. Can you give us an idea of where the body of evidence is in terms of peer-reviewed science.

[1150]

A. Morton: I can only repeat that in the literature I reviewed, there's one paper by Alasdair McVicar, who wonders whether perhaps it's not sea lice. But in terms of the people who've done the fieldwork, who have had the hands-on experience…. I think they outnumber 30 to 1 — the number of papers that feel there was impact.

Most recently — and you should get a copy of the convener's report that came out of NASCO, which is the North Atlantic Salmon Conservation Organization…. They say that the salmon farmers have finally admitted that there is severe impact by salmon farms on wild fish. They go on to say that it's not enough to just reduce that impact and that you have to remove it. That's Malcolm Windsor.

I think that you just have to look at the amount of literature yourself. I will only repeat, again, that it's overwhelmingly in support of this being a very serious problem.

K. Brooks: We've gone from unequivocal consensus to overwhelming support. That's a step in the right direction, I think.

There are two reports…. I didn't come prepared to answer this question in a great deal of depth, or I would have brought more citations. But there's a report by Shona Marshall — I believe it's 2003 — in which she examined sea lice on wild trout during years salmon farms in the sound she was working in were in operation and in years when the salmon farms were not in operation. She found no differences in the abundance of lice on the wild fish when the farms were fallow, as opposed to when the farms were in operation. She concluded that the farms were not the source of the infection, that the source of the infection was wild fish.

There's a fellow named Costello that I referred to earlier. He has published several papers on his work in Killary Harbour, in Ireland, in which he has done drifter studies, looked for copepodites. The lice are hatched from eggs. They go through two naupliar stages, which are called lecithotrophic. They're feeding on their internal yolk reserves in the egg; they don't feed. They develop through two stages and then molt to the copepodite stage. That's the stage that can infect fish. It takes four to five days for that to happen.

In the Broughton Archipelago I've spent too many months sitting on a transect line, which is a rope tied to a salmon farm, letting it in and out and struggling to manoeuvre the boat, to hold it on a transect, because the currents are so strong that it's like water-skiing behind a speedboat — currents of 1½ knots.

Not all the time but frequently, salmon farms are put in well-flushed areas. These little naupliar larvae have little tiny setae on their maxillipeds and their antennae, and they use those to try and swim. They are very feeble swimmers, and there is no way on God's green earth that they are going to swim against currents of 1½ knots where I have trouble manoeuvring my boat with a ten-horse kicker on it to maintain a transect line.

I don't know what the infection rates associated with salmon farms are, because I can't quantify the background sea lice levels. But what I can tell you is that except where the resting current vectors…. You throw a watermelon in the water, you watch it for three or four days, and you see where it goes. The average distance and direction that it goes is called the resting current vector. At the average resting current vectors that we see, we would expect those copepodites to first become infected probably somewhere around six to ten kilometres from the farms, not at the farms. That's the first point I want to make. I'm sorry I got sidetracked there.

[1155]

With respect to the European literature, what Costello found in his drifter studies was that the nauplii — these first stages he saw at the salmon farm where he was doing his studies — were actually swept out to sea and didn't enter the harbour. He found very high concentrations of copepodites right around two river mouths which were located eight and ten kilometres from the salmon farm. His conclusion was, again, that there was some kind of a resting stage that enabled the sea lice to congregate around these natal streams where the Atlantic salmon and sea trout were coming out so that they could infect them during their out-migration in the spring. He said that he found no evidence that the salmon farm was…. He found no copepodids.

I think in all of his studies he found two copepodids at the salmon farm — lots of nauplii but only two infected organisms. His conclusion was that the farm was not the cause of the sea lice infection on these trout and Atlantic salmon, but rather, the infections were associated with wild sources of the lice.

My point is not to make a conclusion about the European literature and what it says. My point is that

there is far from a consensus in the European literature. Karin Boxaspen is a very conscientious researcher in Europe who I have frequent communications with and, like DFO here, she's continuing her studies because she's trying to unravel this ball of twine. She would not agree that there is a consensus in Europe that salmon farms are the cause of the problems with their Atlantic salmon.

The other thing I'll say — briefly; I realize I'm talking on too long — is with respect to this data. I was a physicist first. I won two prizes from Edward Teller for my imaging of the thermonuclear burn in the Lawrence Livermore laser fusion program. We used to pump down our target chambers to where we were scavenging individual ions out so that nothing would interfere with the propagation of the laser beam and its interaction with the target. Very clean science.

When I entered the world of biology, I was overwhelmed with the complexity of everything we do. Not only can we not control all of the variables that influence the results of our studies, we don't even know what all those variables are. The trick in science is not to scavenge individual ions from the environment to achieve super clean studies. The trick in science is to be able to gain information from what I call the fuzzy data that we get. It's fuzzy because we are looking through a mist created by all of these unknown variables. You folks, unfortunately, have to deal with that. It's a fact of life.

We could study this for the next ten or 15 years, and you are not going to get precise, clear-cut algorithms with 99-percent coefficients of determination defining the risk posed to pink salmon by salmon farms. It's not going to happen. You've got to try and understand the literature, and you've got to try and see through this haze and glean appropriate information.

G. Robertson: In that same vein of fuzziness…. I'm a little confused when you're referring to several specific papers coming out of Europe. My question was more on the whole body of evidence. Ms. Morton referred to a very significant ratio, 30 to 1, or that the vast weight of evidence is on the side that there is impact — not that there's a direct cause.

I don't think causal relationships, as Mr. Krkošek pointed out, are the issue here. It's whether there are impacts, and by the sounds of it, the PFRCC findings were that there is enough impact to justify those options. Fallowing was what was implemented.

If we're talking that there is impact, Mr. Brooks, can you comment? Is the majority of that body of evidence from Europe indicating that there is impact, as far as you know?

[1200]

K. Brooks: My own assessment of that body of literature would be: yes, salmon farms certainly have the potential to impact wild stocks of fish. If lice are uncontrolled and unmanaged, there is a potential for sea lice to adversely affect fish. With respect to the PFRCC document, I'd like to call your attention to the fact that when this issue first emerged, there was a great deal of concern expressed, based on a precautionary approach to solving the problem.

We're now — what? — five years into this, three years of study into this, and it's my understanding that DFO, of which Brian Riddell is a part, has recently issued a statement on its website saying that the evidence DFO sees, after looking at the issue for three years…. Now, we're not talking about responding to allegations of the collapse of pink salmon fry. We're talking about, based on the science that we've been collecting, DFO saying: "We don't see that. Our evidence doesn't support other published reports asserting that there is an imminent danger to pink salmon stocks."

In Washington State NOAA Fisheries has issued an opinion that, based on their assessment of all of this literature, they do not see evidence suggesting that salmon farms are creating a significant danger to pink salmon runs.

The Fraser council, after the Pacific Salmon Forum, John Fraser's forum…. I'm in fairly constant contact with Jon O'Riordan there. They are now stepping back from a pure focus on salmon farms as the cause of these problems and taking a more ecosystem-based approach to try and understand the issue. The focus on salmon farms has not led them down a path that is clearly elucidating the problems, and it's obvious to them that there are other factors operative here which are influencing these stocks of pink salmon.

Just a real quick summary. The more we look, the less certain we are, I guess, is the way I would put it today. I don't think any of the scientists here are ready to say that sea lice have no potential effect on pink or chum salmon runs in the Broughton. What I'm saying is that we don't see an imminent danger to those stocks. The more we look, the more we realize that there are many factors affecting those stocks, not just salmon farms and sea lice.

G. Robertson: What continues to baffle me here is that, despite the majority of the literature in Europe indicating an impact and some degree of concern, and — from what we understand on the panel — the majority of the literature on impact on the youngest or smallest of chum and pink in the Broughton…. In that peer-reviewed literature, we have majorities on both that point to a concern and an impact.

Yet DFO's position is, at this point, that we don't need to worry about that concern, or that, even though the majority of the literature supports that concern, DFO is not concerned. Is that accurate, that the danger is not significant enough for us to be concerned about the impact of sea lice on wild pink and chum?

R. Beamish: Who are you asking that question of?

G. Robertson: Well, the DFO.

R. Beamish: Maybe Ken is the most appropriate, because I'm not DFO — right? I'm Dick Beamish here talking about science. If you're asking me to comment on what you said, whether your summary is right, I

would say that no, it wasn't. You just heard very clearly from Ken Brooks that there isn't that consensus.

I'm on the PFRCC. I sat there when they wrote the report. I know what happened in the room, and we did not have the scientific evidence to indicate what you said. There was concern in the room, and people wrote that report based on their opinions, really.

[1205]

I can't comment on behalf of DFO; I'm just a scientist within DFO. But in all respect, the summary you just had…. I wouldn't agree with it as a scientist — all right?

G. Robertson: My summary, I guess, stems from the preponderance of fuzziness around this issue, as both the scientists and the politicians are grappling with right now. Given that this is fuzzy and given there will never be consensus, we have to weigh this. Should we be more concerned or not concerned? Clearly, the body of literature that has addressed this demonstrates that there's reason to be concerned.

Any more comments?

S. Jones: Yeah. I've also looked at the literature, and I think I've read a lot of the literature, both in Europe and what's beginning to be produced in Canada now, and there's no question that there is a lot of literature that relates sea lice on wild populations of salmon and the presence of salmon farms. There is also literature that questions that relationship, and perhaps some of the differences may reflect the peculiarities of different locations.

We've heard a report cited this morning of a Scottish study in which they concluded there was no relationship between lice on salmon farms and on wild salmon in that locality, but there are other studies from Scotland and from a different loch system where that relationship has been shown, and it's been shown repeatedly. So I think there are local conditions that reflect this as well.

The Norwegians have been working in some of their fjord systems for many years now, looking at the relationship between lice on farms and what occurs on wild Atlantic salmon or sea trout smolts. There was a publication from a series of Norwegian authors that came out early last year that summarized seven years' worth of this surveillance data — it's seven or nine years — as a prolonged database of Norwegian information that associated lice on farms with what was on salmon.

Their conclusion was that there is convincing evidence of an association between sea lice on the wild salmon in some of the fjords and those on farmed fish. But they made a very clear distinction between the presence of sea lice on the wild fish and the impact that those lice are having on the populations of wild salmon.

That's a very important point that I'm not hearing being made here. It's the distinction between the presence of lice on wild fish and its association with sea farms and the impact of that population on the population of wild fish. The Norwegian study, based on the several years of work, concluded that it was very difficult to make a link between them, despite the associative data that they have — the correlative data between salmon farms and wild smolts. It was very difficult, and they could not conclude that there was an impact on the wild salmon population. That is an important distinction between the infection of sea lice and the impact that that infection is having.

In my opinion, I suspect that the difficulty relates to the fuzziness we've heard, and specifically to the fact that many factors influence the survival of wild salmon populations. It's extremely difficult to tease apart the contributing factors of sea lice from the other, sometimes unknown, factors. There's a lot of evidence in the literature. Some supports; some doesn't support. But I don't believe there's a lot of evidence that supports an impact on a wild population.

M. Krkošek: Can I make a comment? There are a lot of statements saying that there's no evidence for impact on wild fish. That doesn't mean that there is no impact. It means that there may not be an impact or that we can't measure the impact.

I think everyone would agree that there are a lot of factors that affect salmon populations. A lot of salmon populations have high fluctuations in their return abundances. In the face of that kind of variability, it would be difficult to detect an effect of aquaculture on a single stock of salmon, because these stocks are going up and down.

But that might be looking at the wrong type of variability. When you look at a region, if it's a good year, it's generally a good year for, say, pink salmon stocks. If it's a bad year, it's generally a bad year for salmon stocks.

The question that really needs to be addressed is: over a course of time, are the salmon stocks that are exposed to the aquaculture site consistently doing less well than the other salmon populations around them? They're all going up and down, but are the ones that are exposed to the aquaculture sites consistently on the negative end of this distribution?

[1210]

That's an analysis that has not yet been done for salmon in British Columbia. There has been an analysis done at a global level, but I'm not an author on that analysis. It's not yet published, so I cannot comment on it at this time.

R. Austin (Chair): I see that our second question that we posed is basically meshed in with the first one. What I'm going to suggest is that I will formally pose it, and we'll go through the panel. For the sake of balance, I'm going to start with Alexandra, because you may want to be able to make some other comments which haven't already been heard. It's again about sea lice, of course.

The second question was: do salmon farms contribute sea lice to the natural environment, and are there other sources or causes of sea lice and disease risks to wild populations? Once again, we have heard a lot about this already, but I would like to give the panellists an opportunity to speak to it a little bit more. Also, I'm going to ask members that we limit ourselves to one question each, and then we'll break for our lunch.

R. Cantelon (Deputy Chair): And no statements, if I may.

R. Austin (Chair): Yeah, and no statements.

R. Austin (Chair): Our esteemed panel is welcome to join us for lunch. We might make it a working lunch, actually. I think Dick has to go for an early flight, so we might make this a working lunch. That way we'll accomplish as much as we can.

A. Morton: Do salmon farms contribute sea lice to the environment? I would say absolutely. Rick and I and another fellow, Rob Williams, published this paper in the *North American Journal of Fisheries Management* on the subject. We looked at the number of sea lice on young fish outside salmon farms that had farmed salmon in them in 2002. Then in 2003 the PFRCC removed those farmed salmon, so I'm looking at fish at several sites where simultaneously there were farmed salmon and then there were not farmed salmon.

In this year you can see the levels of lice on the wild salmon have collapsed. In 2004 they put those farmed fish back, and the levels came back. Yes, there's some fuzziness. You've got weeks going across the bottom. There were not as many lice initially, but eventually they did build up to very high levels on the young fish. Data like these are so stark. They certainly deserve critical consideration.

The next question we've been grappling with here is: did the young salmon that went to sea lice–free survive better than the other years? This is the opposite of: do lice kill fish? In the Broughton when the fish don't have lice on them, what happens?

Dr. Beamish provided us with that answer. He looked at only one age class. I wish he had looked at more, but he looked at the young fish that were treated to the fallow. These fish were spawned in 2002, and they went to sea in 2003 when the fish farms were removed from what we figured was the major migratory corridor. They returned to spawn in 2004. He says the combined estimate of 34.2-percent survival for this brood year is exceptional and may be the largest survival of pink salmon ever recorded. This is DFO's own answer.

Are there other causes of sea lice and disease in wild salmon? Of course, but this picture you see right here is due to salmon farms. Most of the lice have only been on this fish a matter of hours. We caught this fish near a lot of mother lice, and we know that the mother or gravid lice live on farmed salmon. I'm not saying they live only on farmed salmon, but we know they are on farmed salmon.

Many are troubled by why sea lice would remain near salmon farms during their free-swimming phase. Dr. Brooks has alluded to this and the difficulty he had in manoeuvring his boat around the high current of farms. But he was probably on a different farm.

In the centre of this cluster of Xs is the Burdwood Islands, and in there is a salmon farm. I dropped little blocks around that farm with various skirts hanging underneath them in a preliminary experiment to see what the tides do with these blocks. Every colour represents a different day, but I've just highlighted here the brown Xs and crosses. That was 12 days after these blocks were deployed.

[1215]

Some of them barely left the salmon farm site. They're only a few hundred metres away. Others are not much farther away and have moved east. What we found was that the surface currents in the Broughton were so complicated that it often captured our blocks and held them there.

Unlike Dr. Stucchi's work, our project tracked surface currents. His project had fixed devices, which I'm sure he'll explain. He got very accurate readings almost to the surface, but both the lice and pink salmon fry are known to reside at the surface.

While DFO insists that there are other sources of sea lice, no one can find them. I don't ever see numbers on where these other sources are and how many lice they have on them.

This gives you an indication of how many farm fish there are in the Broughton Archipelago compared to how many wild fish DFO says are there. The red line at the bottom is how many wild salmon of all species that DFO has counted in the rivers. That yellow line is approximately how many farm salmon are in the same area during these years.

I've used a very low estimate for my farm salmon. The farmers won't tell me how many fish they have, but if we say that only 15 of the 27 farms were active on each of these years and that they only had 500,000 per farm — and I know that some of them have up to 1.3 million — that yellow line is how many farm salmon compared to wild fish. There's a lot more farm salmon in the Broughton than there are wild salmon.

This is what some of the sticklebacks look like in the Broughton. All those little things hanging off of him are sea lice, but they're young sea lice. Nobody has ever shown me a picture of or told me they had found a single gravid louse on a stickleback. If it has occurred, it's very, very rare. I've handled hundreds and hundreds of these little fish, removing them from my net. Gravid sea lice are up to a centimetre long. You can see them.

If sea lice cannot make eggs while riding on a stickleback, sticklebacks cannot be part of the problem. Millions and millions of farm salmon are known carriers of sea lice, and they're in the Broughton year-round. To ignore them, I think, is not a wise thing.

DFO is also on the record saying that the Broughton is too fresh, too low-salinity, to support sea lice. But this ignores that (1) the lice are actually there and (2) there's no data to support this. If you look at the months from March through the end of May, which is the peak migration time for the juvenile salmon — that's their time of concern — these are the salinity levels that I've recorded. They correspond very closely to what DFO reports. They're from 28.5 up to a high of just over 30.5 parts per thousand.

The optimal level for sea lice is 30, the yellow line. Too fresh is down there. It's not even on this graph. It doesn't occur in the Broughton in those months with

any consistency in the area of the salmon farms. You can be in the Broughton in March and record fresh levels, but you have to go right up to the rivers. That's not where we're seeing a sea lice problem.

There really is no debate. Sea lice live on farm salmon. We know that. Farm salmon far outnumber adult wild salmon. We know that. Young wild salmon are heavily infected near, and only near, salmon farms. I still want to hear where DFO have done their study that they didn't find sea lice near salmon farms.

Just separate the farm salmon from the wild salmon, and sea lice plummet and wild salmon rebound. If someone wants to prove this is wrong, let's run that experiment again. In 2003 they removed farm salmon from a corridor. Let's do it again in 2007 and see what happens.

R. Routledge: I want to talk about evidence from Scotland, British Columbia and Ireland to give a more international perspective to this. First from Scotland. This is one of the studies that I suspect Simon was referring to — Loch Shieldaig. You can see two farms there, one in Loch Shieldaig and one around the corner from the so-called Wee Narrows. There are two rivers there. There's the River Shieldaig coming at the bottom and another one called the River Balgy around to the right, which is off that picture. Those farms are managed according to an area management agreement, and they're harvested synchronously every second year.

[1220]

On the left there is a graph showing density of sea lice larvae in sites around those river estuaries. You can see in year two, when the salmon have been in the farms for a full year and a half or so, there are lots of lice larvae — especially in 2001. In year one of the cycle there are no lice. What's the explanation? It has to be the farms — right?

Look at a more local level. Around this farm you can see lots of lice on the farm. The farm was treated around weeks 45 and 46 in 2001. Lice levels on the farm dropped. Lice levels around site A, not too far away from there, peaked around the time the farm was treated with SLICE, and then they dropped off.

Nauplii. I took a copepodite ratio. If that ratio is high, that means there are lots of these little nauplii around compared to the copepodites. It means you're probably close to the source. The lice haven't had a chance to mature into copepodites. Where is the ratio really high? It's at site C. Where is site C? It's right near the farm. Where did the lice come from? Probably the farm.

Here's another really interesting graph showing something much different. This is average larval density at a number of different sites, and one is off the scale compared to the others. That's site S. That is the estuary of the River Shieldaig where these little fish are going to come out. Ken has referred to the fact that somehow they seem to be able to congregate there.

The Scottish scientists tried to do a hydrodynamic model to see if the lice could just somehow get blown up there on a northwest wind. The pan of the bottom there shows high numbers of lice around that shore of the inlet that does contain the estuary.

I suspect there's something more than passive transfer going on there, but that's really anybody's guess. People don't know very much about how these guys certainly don't swim against the tide but maybe take advantage of tides by hiding out when the tide is going the way they don't want to go.

What about the Broughton? I want to show a picture from Dario's paper that he wrote with several other authors — an excellent paper, in my opinion. All those arrows here, which I think — Dario, you can correct me if I'm wrong — model roughly late-spring sorts of flows. Then you can see all the arrows, most of them pointing down towards Queen Charlotte Strait, and you might think, well, that's where these little guys will get carried.

But have a look around the Burdwood farm area, and you can see, if you've got good eyes — better than my old eyes here — some gyres and eddies in there. No currents up bays, like that one there, and even the lack of current back up to Tribune Channel from Glacier Falls farm.

Furthermore, Dario and his co-authors pointed out that in other experiments with weaker, less buoyant flows in Knight Inlet as you would get early in the spring, the surface flow seems to reverse in Tribune Channel. Alex's blocks, which she talked about, did in fact show that at times.

Here's another little graph that Alex sent me to demonstrate what happened to some of these blocks when they were released around the Burdwood farm in red there. You can see some of them ended up going up towards the Viner River. Down from the Viner River come Viner chum, and you've got a potential for impact right in there.

Is there an impact at a population level? Well, here's a graph. Burdwood farm established at the vertical line near the right there. After that, very poor returns with no commercial fishing to intercept those fish, except for a little rise in the last year. You count back to when those fish went out to sea. That was when the fallow was in place. That's not a definitive graph all by itself. There are lots of big fluctuations there, just as everybody's been talking about.

Don't just look at the one piece of evidence by itself. Here's some evidence from Ireland — same sort of picture. Fish farms start to ramp up. In this case it's the sea trout. They start to go down.

R. Cantelon (Deputy Chair): I didn't give you your one-minute….

R. Routledge: That's my one-minute warning, is it? I think this is my final slide anyway.

Yes, they do contribute lice to the environment, and they have impacts at the population level.

[1225]

M. Krkošek: This question here has been a central focus of my research over the years, and we've taken an approach of sampling juvenile pink and chum salmon as they're migrating past salmon farms.

On the upper right-hand corner there, you can see a chart with stars on it. Those are sample sites. At each sample site we collect the juvenile salmon and count the sea lice on them. We enumerate the copepodid, chalimus and motile stages. These are juvenile lice, middle-aged lice and older lice.

The pattern you see in the data is one that corresponds to a story of juvenile salmon migrating past the salmon farms, becoming infected as they pass the salmon farms and carrying this cohort of lice with them as they go out to sea.

When you look at the top panel in the chart on the left, you see a low abundance of copepodids before the salmon encounter the farm. The farm is located at X equals zero, and salmon are travelling from left to right. As they pass the farm, you see a rise in the copepodids, indicating local transmission of lice.

As you move down to the chalimus lice, you see that rise in the chalimus lice repeated slightly down from the farm. Then finally, for motiles — the adult stages of lice — you see a rise in those lice further on down the migration route. You also notice there are lice in the environment way up the inlet before these fish pass the salmon farms.

You can take these data and analyze them with models that have these components in them — that have dispersion of lice, that have migration of fish infection and development of the parasite — and you can get fits of the model, which are shown there in the top right, that capture all this information and then can give you inference on where these lice came from.

The story is consistent across all the work we've done that there are lice originating from salmon farms and that there's a background ambient infection pressure of lice, meaning that lice are coming both from salmon farms and from natural hosts in the environment. You can tease apart these two sources of lice and gauge what the relative transmission of lice is from farm salmon to wild salmon.

That's what the bottom right-hand panel shows there. It shows, first of all — the thick blue line — the overall distribution of lice in the environment. Fish would be travelling from left to right. Then there's a rise in the red line around X equals zero, and that's the footprint of lice originating from the salmon farm. Then there's a background ambient infection pressure — lice originating from natural hosts. That's the horizontal black line there.

We've repeated this kind of data collection and analysis several times over multiple years. I'm just going to fire through a whole bunch of graphs. The idea isn't to look through all of these but to notice that the same pattern is consistent across all these data sets, showing the same story.

Here are four replicates of that kind of sampling strategy and the fits of the model. Here are the resulting spatial distributions from those sources of lice: first, the source of lice from the farm, the spatial footprint around zero and then the background infection pressure — the horizontal distribution of lice there, which corresponds to lice coming from natural hosts. That was from 2003.

Here's from 2004. We've got three farms on the migration routes. High-resolution data, lots of spatial coverage, same models, same story. But now we have three footprints from the farms along this migration route. This is for chum salmon in 2004.

[1230]

Pink salmon, 2004 — same patterns, same story. Here we go, for 2004, down a different migration route, Knight Inlet — similar patterns, similar story. For chum salmon in 2005, going out a different migration route — similar pattern, similar story.

The story that's consistent is that there are natural sources of lice in the environment, that farms are a source of lice in the environment and that we're able to estimate the relative contribution of lice from these two sources.

In these years and these data sets, salmon farms were overwhelmingly the primary contributor of sea lice to the migrating juvenile salmon. These results have been published in two papers. One is in the *Proceedings of the Royal Society of London*; the other is in the *Proceedings of the National Academy of Sciences of the U.S.A*. I have reprints of these here, and you're welcome to take a copy home with you.

S. Jones: I'd like to make three points, but first of all, I'd like to state that I agree that from all the information I'm aware of — in Canada, Chile, Scotland, Norway, Ireland — there's no question that farmed salmon become infected with *Lep. salmonis* and that gravid females are often found on farmed salmon. There's no question. Farmed salmon can be a source of planktonic larvae in the water surrounding the salmon farm if left untreated. That's a very simple answer to a question which is obviously quite complex. Under certain circumstances, there is no question that farmed salmon can be a source of *Lep. salmonis*.

I'd like to just talk a little bit about some of the uncertainties. Really, what we're talking about is: does the evidence we have support that, and are there alternative explanations to evidence that we're seeing? Although intuitively we recognize that the farmed salmon can be a source, does the evidence support it?

One of the most important pieces of information we saw this morning, I think, was the horizontal yellow line that showed the consistency in the numbers of farmed salmon in the Broughton Archipelago over the years — whatever those years were. We also heard that there was a fallowing in place in 2003, and our data from our surveillance program showed that in 2003 there were very few *Lep. salmonis*. In fact, there were more *Caligus* on our juvenile pink and chum salmon in 2003 compared to 2004.

In 2004 the fallowing was not in place. We saw a massive increase. We heard the story this morning of the massive increase in the numbers of lice on pink and chum salmon, particularly the *Lep. salmonis* louse. This has been published in the literature, and it does support the possibility that fallowing played a role.

What we haven't seen, though, is data from 2005 and 2006, which we've collected but have not yet published. That shows that in 2005 there was a decline in the overall abundance of *Lep. salmonis*, approaching

what we saw in 2003. In fact, in 2006 the levels of sea lice are below what we saw in 2003 when measuring *Lep. salmonis*. To my knowledge, no fallowing was in place in 2005 or 2006.

While the 2003-2004 data does support the possibility that fallowing can be measured by looking at overall levels of lice, the decline in 2005 and 2006 in the absence of fallowing suggests very strongly in my mind that there are other processes involved that regulate the year-to-year fluctuations in levels of lice on pink salmon. This is an uncertainty as to what exactly that is. It may be salinity. It may be temperature. It may be the abundance of the wild fish migrating population that supports the different lice level in different years. But clearly there are other processes involved besides the presence or absence of fallowing. Certainly, the consistency in the numbers of farmed salmon suggests that they may not be the prime drivers here.

The second point is on work we published on sticklebacks. We published this in the *Journal of Parasitology*, and we showed that sticklebacks are a very frequent host of *Lep. salmonis*. We also published data on salinity at the points we collected sticklebacks throughout the Broughton Archipelago. We showed that there was a very significant spatial variation in the abundance of lice on sticklebacks.

In certain areas of the archipelago, consistently low levels of lice. We repeated this at three different sampling periods. Other areas where the levels of lice on sticklebacks were very high we collected salinity data at the same time as we collected the sticklebacks, so we have a lot of salinity data for that year and for other years. What we found was that, very consistently, the lowest levels of lice are always associated with areas in which the salinity of sea water was lowest.

[1235]

These are areas that are further inland or upstream within the Broughton Archipelago. Typically, the salmon farms are located in areas with higher salinity. Our data on sticklebacks, which we assume to be non-migratory — we're not quite sure yet — suggests that salinity in the archipelago plays a very significant role in regulating abundance of lice on sticklebacks.

The final point I'd quickly like to make is that for farmed salmon to serve as a source of sea lice, we have to have some information on…. Not all farmed salmon are equal. A newly installed population of farmed fish, the so-called smolts, tend not to be infested or tend to be infested with very low levels of lice. Second-year Atlantic salmon, if untreated, tend to have much higher levels of lice.

We need to know more about the status of the farmed salmon. Were they first- or second-year? Were they treated? When were they treated? What are the lice levels on these farm fish? These are areas of uncertainty right now that, in my mind, force us to question the link that's been made to date between spatial differences in abundance of lice and the presence or absence of salmon farms.

R. Beamish: I had to read the question again because I wasn't sure exactly what it was. I don't really study the transfer of sea lice from the farm to wild salmon. However, there's a second part of the question that asks about the sources of the sea lice.

What we have been doing — and I didn't bring a PowerPoint presentation — is looking at sea lice development on Sargeaunt Pass farm. I'm sure you know where that is — right? The reason that site is so important is because…. Again, you know that Glendale itself is the major producer of pink salmon, so that's an obvious area to do research.

We have just completed a two-year study of Sargeaunt Pass farm. The fish, I think, were first put in the farm about March or April of 2005. I'm telling you this because for the first year, 2005, there is no evidence that any of the sea lice on the fish in the farm came from within the farm.

All of the sea lice on the farm in Sargeaunt Pass in 2005, right up until the end of December, had to come from some external source. The external source could be wild sources, or theoretically, they might have come from some farm somewhere else and gone up current. I don't know. I could show you the data if we had time.

The sea lice did develop on Sargeaunt Pass farm, beginning in January and February, when the salinities in the area exceeded about 30 parts per thousand. Whether or not that is the reason for the increase…. Of course, there's more work to be done. The farm was then treated with SLICE at the end of February and again in March. Basically, it eliminated the sea lice until the present.

There clearly is a source of sea lice that has to infect farms, as you know. In the Sargeaunt Pass farm in 2005 the sea lice came from outside of the farm.

The second part of the question relates to sources. It's already been mentioned that we have done some work looking at sea lice levels on wild salmon. I think you probably have seen one of the papers that we published. Of course, sea lice are extremely common on adult salmon coming back.

You may not have seen the paper that was just recently accepted by *Aquaculture*. I'm just making the final changes to it. It looks at what's called a life history strategy of sea lice. In that paper there are a number of things. We confirm the results of the study on adult salmon in the coastal areas. But we also show that right in the middle of the Pacific, along with some studies….

A very nice study was done by a Japanese scientist named Nagasawa. We repeated his study ourselves in 2005. We went out on a Japanese research vessel and looked at sea lice levels on salmon in the middle of the Pacific.

[1240]

Sea lice levels, for example, from that study on juvenile pink salmon in the middle of the Pacific…. Some 90 percent or 95 percent of the pink salmon in the middle of the Pacific have sea lice, *Lepeophtheirus salmonis* — I think an average of eight or nine sea lice.

We know that sea lice are very common on salmon. The paper that's accepted is our idea of how sea lice find their way into the coastal areas. We argue that that is part of the sea lice's life history strategy, and we

think that explains why this animal is so successful in the Pacific.

A puzzling part of our work, and Ken Brooks already mentioned it, is the concept of a diapause stage, as it's called — in other words, an overwintering stage. Can the sea lice be brought into the coastal areas? Does it have the ability to overwinter?

The literature would suggest no. There has been no diapause stage reported for any parasitic copepod, but maybe like Ken Brooks suspected, there is something there. That's about as far as we've gone with our studies on how sea lice are transferred from wild fish onto other fish.

D. Stucchi: I've got a bit of a PowerPoint presentation. It isn't fully organized, but I think it covers some of the topics that I want to discuss.

To answer the first part of the question, I think there is consensus. There's no disagreement that farms do contribute sea lice. We've heard several people discuss that. I think key to the problem — and Marty has alluded to this as well — is how they're distributed and dispersed from those farms.

As you've heard, I together with Mike Foreman have been modelling the circulation in the Broughton as well as taking observations of the circulation of the Broughton. Some things have emerged quite clearly from that. One is that in the surface layers — and Rick Routledge showed you one of our earlier diagrams — of this area there's a persistent, and strong in some places, seaward flow — an estuarine flow of waters moving from the east to the west out to sea. We see that in the observations, and the models actually reproduce that as well.

The agreement between the model and the observations is variable. It's stronger in some places and weaker in others in the observations, but there are explanations for that — reasons why the model and the observations don't align completely. But they do agree, and they both show a consistent seaward flow.

This is important for how you distribute…. We've heard about the naupliar stages. There are two naupliar stages after the eggs hatch and before they become infective. Their duration depends on the temperature, and their survival depends on salinity. But the temperature dependence at roughly 7 to 8 degrees is about four or five days, I believe. That's the length of time. They don't swim very well. They're weak swimmers, as Ken pointed out, so they get dispersed by the currents.

We've done some simulations using our model currents to see where those particles would go. This is one simulation from Doctor Islets. The top panel shows you the release site, the top left. Doctor Islets are just at the junction to Tribune. We've tracked them for several days — I think five days in total. So the different colours are the tracks one day at a time. You can see that after day one, the particles move partway down Knight Inlet; day two, almost starting to reach Queen Charlotte Sound. By day five, most of the particles are out in Queen Charlotte Sound. These are model simulations. These aren't actual data.

About day five is when they would become infective, so they're well removed from the area of the farm. Marty quite clearly shows in his data that there is a higher infestation rate near the farms. I should also mention that the DFO sampling program carried out by Brent Hargreaves also sampled throughout the Archipelago. He doesn't always see the same consistent pattern that Marty has shown. You learned about this last week from Brian Riddell.

[1245]

We know, for example, in Knight Inlet that our surface flows are too strong. That may explain why they are moving out very quickly. You do see evidence in Brent's data and, I think, even in Marty's data that there are high infection rates downstream of the farm, which would be consistent with this kind of picture.

I wanted to show you another simulation done from the Glacier Falls site. Now it's taking longer for the particles to…. The Glacier Falls site is in the top-left panel, partway at the western end of Tribune Channel. Once again, the colour-coding is now by two days. By day nine or ten, the particles are well out into the strait. They become infective, if you recall, about day four to five, so panel C and D is where they become infective.

You can see, I think, some consistency with what Alexandra showed — that there are some infective particles around the Burdwood Group. It is known, and the model shows, that there is a convergent zone around the Burdwood island group, which is that cluster of islands in that top-left panel.

There are areas where they can coalesce. We put some drifters out in the ocean. This is what we put out to track these particles. There is one in the water. It has a GPS antenna and transmits its position, and we follow it. We released some of these sites in Knight Inlet for 31 hours and tracked them. You see large up-and-down inlet motions, dependent on the tides and also the winds. But after 31 hours the release point is where those black squares are. By the end of the experiment they were down near the junction, so they did move seaward. But this is a very short experiment. There they are in the ocean.

This is the one I wanted to end with. We did releases around the Doctor Islets farms. Now, these are actual observations from the field. We released five drifters around the farm. Several of them wound up on the shore, as you saw in that one where it was hung up on the kelp. So we had to stop the experiment, remove it from that location and redeploy it. Sea lice nauplii don't get hung up on kelp, as far as we know, so they can freely move. They're very tiny compared to these drifters. We have to practically remove them when they hang up on the shore.

We did this a number of times. I just wanted to show you that this is only after nine hours. Two of the five drifters were heading to the south and west from the farm. In fact, I think they were heading down towards Minstrel Island. The third one in red went around and was heading westward as well, by Doctor Islets, so we had to stop the experiment. Several of the

others wound up on shore. The ones that wound up on shore would mimic a potential source of getting lice in close to shore, where they may be retained in the shallow waters of the shoreline.

We're seeing quite a large variation in dispersion pattern downstream, some in close to shore, influenced by winds and tides. It's a very complicated problem. There are mechanisms to retain lice larvae close to shore, but there are also mechanisms that transport them downstream. I think that is not inconsistent with the observations we've seen. We see increased infestation levels on juveniles near the salmon farms, inferring that the salmon farms are a source. Infective copepods are there. We see them downstream as well. The data seem to show that.

As a final comment, if I'm permitted, we went looking for sea lice larvae, the planktonic versions. We dragged nets through the water trying to find them, in the belief that if we could understand their behaviour, we'd be able to better make the connection — if there is a connection — between the salmon farms and the infections on juveniles. We chose the Burdwood island group — the same group that Alexandra showed you, where she dispersed her floats from. We used that whole area.

We sampled quite intensively around that farm, and we sampled in many other locations. We were unable to find them, I think in part because our methodologies may be lacking in some way, though we don't understand how. But they are difficult to find, though we're going to continue to do this. There is an expression of interest to continue this work in the coming years, to actually try to find the larvae. It's a complicated picture we're trying to present. I think we're learning a lot, but we're asking many more questions as we go along.

[1250]

K. Brooks: A couple points. First, there has been a great deal of reference to the European literature and to the European experience with sea lice. In Europe sea lice are a significant problem for salmon producers. They cost somewhere around 15 million kroner, I think it is, per year to the industry in damage to product.

In the Broughton Archipelago prior to 2001, when this emphasis on protecting wild stocks became needed, sea lice had not been a significant problem, and there had not been much need to treat them — about one per year prior to 2001, I'm told.

The point is that we're looking at two different environments, two different sets of conditions. It's difficult to infer direct relationships between what happens in the Atlantic and what happens in the Pacific, particularly because the wild species, I think, as Simon discussed earlier, are quite different.

The second point is that in all of this data you see that the sea lice larvae are dispersed from the farm before they moult to an infective state. I have tried to encourage the forum, Marine Harvest, Simon and Dario and everybody who will listen to me that we really need to do what Costello did and look for non-dispersive environments for aggregations of these sea lice larvae.

Those are going to be in places like Bond Sound, perhaps up in Sargeaunt Pass, deep in the inlet there — places that are semi-protected where we have very slow currents that will not disperse the larvae as rapidly as they are dispersed in these channels where salmon farms are located. The salmon farms are located there specifically because the sites are dispersive. They bring oxygen to the fish, and they carry metabolic waste away. The farms are located in dispersive environments.

If we could get away from focusing solely on salmon farms in this issue and take a more generalist ecosystem-based approach to try and understand this issue, I think we would make a great deal more progress.

Someone referred, without talking about it, to Venn diagrams. For disease to occur, you need a circle which represents environmental factors, one which represents parasite or disease vectors and a third which represents the host and the host's susceptibility to disease. You find the epizootic disease where these three circles come together and overlap. In the centre there'll be a little shield shape, and the size of that shield represents the potential for disease. We need to find where there are aggregations of these larvae that are infecting the fish or aggregations of the adults.

Earlier it was stated that because we haven't found gravid female lice on sticklebacks, they cannot be a source of infection. Anecdotal evidence to date — and I think a reasonable amount of anecdotal evidence — suggests that there is motile-stage transfer of sea lice from one host to another. The people actually monitoring the lice on the farms certainly see this in the tubs. They see lice move from one fish to another.

If you look at an inshore area where things can be trapped, that's where you may find high concentrations of sticklebacks and, therefore, high concentrations of lice. That's where these juvenile salmon are migrating, particularly at these small ages, in the nearshore environment, where they're protected from predation. That's probably where you're going to see this disease transfer taking place.

My plea to everybody involved — and I think DFO has been doing this more and more — is to take the more holistic approach to understanding this problem. Get back to basics about disease transmission, host susceptibility and environmental factors. Take that approach, which will be, I think, much more efficient than the approach we've been taking.

[1255]

The last thing I want to say, very quickly, is that Dario alluded to the estuarine flow — the surface flow of low-salinity water out of the environment — out of the Broughton Archipelago. I have brought and will leave with you a summary of salinity, temperature and dissolved oxygen data taken using well-standardized electronic monitors at Sargeaunt Pass and Humphrey Rock. I think you'll see that salinity decreases much faster earlier in the year than has been suggested in the discussion here today. This data is collected at half-metre intervals.

R. Austin (Chair): Thank you very much. I'll ask members if they have one question each.

G. Coons: I'd like to focus myself back on the questions. We can see that the contribution of salmon farms and sea lice…. There is a connection.

One thing that Ken sort of got into was the disease risks. I know that Simon was doing some research about cultured and wild fish disease and the interactions in the Canadian marine environment. I'm just wondering if he could go over some of the knowledge gaps. Or do we know everything about disease transfer and the potential hazards to our wild stocks?

S. Jones: The answer to that is no, we don't. In fact, it has really only been as a result of our interest in understanding interactions between salmon farms, sea lice and juvenile pink and chum salmon that we've really begun to focus our attention on other aspects of the ecology of these small life history stages of salmon.

One of the studies that we've done over the last year is to sample juvenile pink and chum salmon and to look at them for evidence of other infections besides sea lice. There's no knowledge of that. That had been a knowledge gap. We're trying to fill that.

What we found is that there are, in fact, a number of parasitic agents that are found within pink and chum juvenile salmon, the same fish we're sampling to do our sea lice work on. At least one of these pathogens, a virus, is known to be virulent. It's IHN virus. It's known to be virulent in other salmonids. We had no knowledge of that before.

What we need to understand, as we talked of earlier, is: how common are these infections in the populations? Does the level of infections vary from year to year or over spatial distances within areas like the Broughton Archipelago? Do these other diseases contribute to mortality, or do they work together with things like sea lice and contribute to mortality? We just don't know the answer to those questions yet, but we are starting to discover that again, this is more complex, and part of the complexity is the presence of other disease agents.

The basic principle behind the impact of any of these pathogens, as we've heard alluded to earlier, is the intersection of not just the bug but also a susceptible host population and an appropriate environmental set of conditions.

Yeah, there are knowledge gaps. There will be for quite some time, but we're starting to see that in terms of disease, there are other infections in these wild populations. These are infections that have not been reported in farmed fish at all, other than the virus.

S. Fraser: Thanks, everybody, for this. I know it's difficult under the time constraints.

I think I heard some consensus that there is potential for sea lice to affect wild salmon from farms. Even though the farms themselves might not be the source, they may be the sink for the sea lice. So they might be a source for the juveniles — that is, if left unmanaged, I think Ken mentioned.

Outside of fallowing, the only management regime that's used that I'm aware of is SLICE. Now, I don't believe SLICE is allowed…. The use is controlled in Canada — CFIA, I believe. There are issues there. Is that the management regime we're talking about as far as mitigating any effect with the wild and sea lice transfer?

I don't know who to direct it to, so go for it.

[1300]

A. Morton: Marty's first paper, which he published in 2005, was entirely done around the salmon farm that was treating with SLICE. The signal still was strong enough that he could see that there were more lice coming from the salmon farms. His numbers were low, but the signal was very strong, which tells you that they're still producing sea lice.

One of the very serious issues that I believe is facing all of us is that all these salmon farms we've shown you pictures of have applied to double the number of fish they want to put in those farms. Even if you take into account the new way of counting farm salmon, which I don't fully understand, they want to double.

If you reduce your lice but you double your number of fish, first of all, you're going to double the problem. What I'm seeing with the SLICE is it does reduce lice. There are far fewer lice on juvenile salmon in the last few years. But for example, last spring the pink salmon from Knight Inlet pooled around the Humphrey Rock area. There were so many of them. You'd go throughout the archipelago, and there'd be a few here and there, and then you got right to where that fish farm was, and there were acres of them dimpling the water.

They sat there. They got infected. Once the lice were adult female size, they dispersed through the Broughton. We were able to follow them because they looked so similar, but size and age of lice…. They started infecting everybody around them. That was a farm we know was treating with SLICE.

The parasitologist in eastern Canada, Mick Burt, tells us and others that these parasites will become resistant to SLICE. We'll have to go to a new family of drugs. Norway calls it a mosaic of drugs — sometimes neurotoxins, sometimes shell preventers. Some are baths. Some are taken internally. You have to switch the whole family, because parasites are known throughout the literature to become resistant to whatever we throw at them.

I don't think "better life through drugs" is going to work in this situation at all. We have studied it. We are looking at it. When Dario went looking for juvenile lice outside the Burdwoods, what he didn't tell you was that they had treated with SLICE inside. So we do know that it reduces lice, but is it enough for the pink salmon? It doesn't look like it. It doesn't matter whether they die of 40 lice or one louse, unfortunately.

K. Brooks: I think Alex brings up a good point. I was chairman of our state's conservation commission for many years and did environmental mediation for Governor Gardner's administration on major issues of statewide significance. They were inevitably pesticide issues.

We were able to successfully mediate all of those issues for the Governor. The approach that was taken was called an integrated pest-management approach. That takes into account all of the information that you have. It attacks the problem in a multifaceted way.

I don't think anyone wants to use SLICE when it's absolutely not necessary. The pesticide should be considered a last resort. I did bioassay studies for Schering-Plough. I'm now under contract to write a couple of publishable papers dealing with the benthic accumulations and effects of SLICE for Schering-Plough Animal Health.

The point I want to make is that salinity appears to be a significant factor affecting the life history of lice. Salinities to the east of Sargeaunt Pass are very typically in the spring 15, 16, 17 parts per 1,000. In this paper, which I will leave for you, it shows that salinity starts to decline at Sargeaunt Pass and Humphrey Rock in April, not the end of May or June.

Therefore, salinity is going to be, I believe, an important factor in this integrated pest-management approach to dealing with the sea lice issue, at least from the aspect of farmed salmon.

In years when we have increased snowpack, ice-snowpack and early spring rains, portending reduced salinities early in the year, we can probably use less SLICE. If we have drought years in which it appears that we're going to have minimal runoff until the glaciers start to melt and that we're going to have minimal rainfall, then we may need to be more vigilant, and the province may want to impose a requirement for more SLICE treatments. That's one aspect of an integrated pest-management approach to this issue.

[1305]

We have looked at lice levels in the Broughton on cohorts of fish that have not been treated. What we have found is that they go into the environment lice-free. If they're introduced in the winter, beginning in February or March they start to pick up lice. The numbers of lice decline to near zero in the summer when glacial melt drives salinity down in the upper layers of the Broughton. The numbers of lice on the farmed fish start back up again in October and November when salinity increases with the return of mature salmon to the archipelago.

What I'm saying is that I don't think anybody wants to use any more SLICE or any other pesticide than is absolutely necessary. As we gain information, I think the province will be able to take more of an integrative pest-management approach to addressing this issue, and that will enable us to reduce the use of SLICE and to help mediate this issue.

A. Horning: Maybe to Mr. Brooks or maybe to Mr. Beamish: if fresh water and lack of salinity kills lice, should we locate farms closer to rivers, do you think?

K. Brooks: If you locate farms…. Siting is really important for salmon farming, as we'll see this afternoon. One of the siting criteria is that you don't want salmon farms near significant salmon spawning streams. The siting criteria that are in effect today are what — 500 metres?

R. Beamish: Kilometres. It's five kilometres.

K. Brooks: Five kilometres? Okay.

R. Cantelon (Deputy Chair): It's one kilometre.

K. Brooks: I've got three answers. Okay. A long way. The reason for that is to protect the out-migrating stocks of fish. So this becomes a balance of management issues.

A. Horning: To Mr. Stucchi: do currents indicate that we should move some of these farms to better locations?

D. Stucchi: No, I don't think…. Well, we haven't looked at it that way. The sites we looked at seemed to be dispersive from what we can see from our initial experimentation, both with the model and also with some of the drifter work. We're getting some particles moving into shore and some being dispersed widely, and I think you'll find that in many locations. Most of the farmsites that are now in the Broughton are located in dispersive locations.

In the early days some of the farms were put in more quiescent locations, and they proved to be not very viable. So they've been moved to more energetic and dispersive locations.

R. Beamish: I think it relates to the next question. We probably could agree that in 2003 wild salmon, if you want, and farmed salmon coexisted. I suspect that we might get agreement on that. There is a question as to why it was successful, and of course there was some fallowing.

There were four farms that were fallow, when you actually look at what was done, and there were 15 farms, if I remember, that were still active. There's no evidence to support that or to not support it, but let's assume that that was true. It relates to your question. If that was the explanation for the very successful marine survival, there are only four farms. Move them. Problem is over, and we all go home.

C. Trevena: The discussion on this has been particularly focused on the Broughton, but I know that there is research happening around Quadra and Cortes, as well, on the potential of sea lice. I just wanted to come back to what was raised earlier on.

Is there any farm or group of farms that you know of that don't have a problem with sea lice, and if so, do you know why this is? I throw it open to all of you, because somebody might know.

R. Beamish: Sorry, I couldn't quite hear. Is there any farm that doesn't have sea lice?

C. Trevena: Is there any farm that doesn't have a problem with sea lice, and if so, where is it?

R. Beamish: Now, could we define "problem" as saying the provincial limit of, say, three mobile sea lice per fish or something? All right.

[1310]

S. Jones: I made reference earlier to studies that had been conducted, and these were not DFO studies. These were studies conducted by other parties, both up the coast in areas where there is no salmon farming but also on the west coast of Vancouver Island in Clayoquot Sound where there is salmon farming. That was the study I was referring to, and in that particular location the occurrence of lice on juvenile wild salmon is quite low, despite the occurrence of farmed salmon in the area.

It's not our work. I don't have the data from the most recent year, but what I did see from two years ago did suggest that this was unlike what we were seeing in the Broughton Archipelago — the occurrence of a farmed population and the absence of what I would call a high level of lice on the wild salmon population.

R. Beamish: I can answer your question. I've already answered it, I think, but Sargeaunt Pass farm, in 2005, did not have a problem with sea lice — defining "problem" as being three mobile sea lice per fish. Now if you talk about why…. I mean, they were the first-year Atlantic salmon. But the answer to your question would be that in 2005 that site did not have a problem with sea lice the whole year.

R. Routledge: One of the reasons why this end of the table has been silent is perhaps that until very recently we had, as independent researchers, no access to information on lice abundances on farms at all. It's awfully hard to answer that question when you don't have the data.

J. Yap: I'll throw this out to anyone on the panel. From this round of the presentation we've heard that there are a number of factors that can kill pink salmon. In no particular order: salinity, temperature, food or the lack of food, predators — and I suppose that includes overfishing. I didn't hear pollution, but I suppose that could be a factor, and sea lice, which is what we're focusing on.

Has there been any study that has ranked these risks to the pink salmon, as they travel through the oceans and back, in terms of the cause of mortality?

K. Brooks: I can't give you an answer specific to pink salmon, but I was part of an international team which spent a week working with NOAA to prioritize environmental risks associated with salmon aquaculture. It's in Nash, 2001. You can go there to get some general guidance, but it's not specific to pink salmon.

J. Yap: To salmon in general, then.

K. Brooks: It's just specific to general environmental risks.

I will tell you that disease risks are one of those risks that we found very difficult to deal with because there's so little known about diseases of wild fish. They just disappear, and we don't know why they disappear. They end up on the bottom someplace being consumed by some detritivore. There are very few good studies of diseases in wild fish, so quantifying those risks is very, very difficult.

J. Yap: Yes.

R. Beamish: Is your question: what are the sources of mortality for juvenile pink salmon? Is that the question?

J. Yap: The question is: how would you rank the relative risks — these are all risks — to the survival rate of a salmon fry? I'm wondering if that's been studied.

R. Beamish: Well, it's a question that…. If it's in general — say, relating to all Pacific salmon species — I think people would agree that that's a very difficult question to answer. I study coho salmon in the Strait of Georgia, and marine survivals can vary from one year to the next — from 50-percent survival through to July to 10 percent.

[1315]

We honestly don't know what causes that mortality in the first few months in the Strait of Georgia. What I'm telling you is common throughout the distribution of salmon. The mortalities can be very high, and then some years they can be quite low. We speculate it's predation or your list, but I think it's fair to say that it's a very difficult question.

A. Morton: One of the extraordinary things we're hearing here is that it's very hard to study what kills young fish, but sea lice are not one of those things that are difficult to study. Compared to whales, they're phenomenally easy, and that's why there's a whole cohort of young scientists who are studying these sea lice. But you have to remember that whatever natural mortality is going on, the sea lice is additional to that. It's not like it would be sea lice or something else.

People who have worked on pink salmon say that they barely survive the coho that come out. The pink salmon come out in March. The coho come out in the middle of May, and they just start gobbling them up. They have to grow very, very fast. Anything that slows them down from growing means increased predation by coho.

I just want you to recognize the extraordinariness of this situation, where we do know what's killing these fish. We can see it. We can measure it. We can hold them and count these lice. As opposed to the many uncertainties that surround these fish, sea lice are very clear, and we're doing our best to bring that science to the point where people can just look at it and evaluate it.

M. Krkošek: I'd agree with Dr. Beamish that understanding the factors affecting marine survival of

salmon…. It's one of the most fundamental and poorly understood aspects of salmon biology.

I think my impression from the literature is that there's a general understanding that early marine growth and survival of these fish factors in prominently in how well cohorts survive. We know that sea lice can affect survival and growth in early marine life. It would be difficult to rank, but I think it's easy to see how these could contribute to reduced survival.

G. Robertson: It's a bit of a digression, but Mr. Brooks, you mentioned Schering-Plough and being contracted to do research there. I don't recall from introductions what your connections are to industry or academia — post-secondary education — and what your sources of funding are — just in terms of knowing where you're coming from here.

K. Brooks: I was director of the fisheries technology program at Peninsula College in Washington State for five years after I graduated, so I have some academic experience.

I have a private laboratory. I'm the sole senior scientist there now, primarily because I'm trying to retire. I have one to six technicians. We do bioassays, fecal coliform testing, lots of physical-chemical testing, lots of invertebrate taxonomy. I've built computer models for a number of industries describing the transport of fate and pollutants and their effects, primarily on the benthos — on macrobenthic communities.

I'm going to guess that 60 percent of the work I do is for various government agencies, and 40 percent of the work I do is for industries, including the B.C. salmon farmers.

I am pleased that Dale Blackburn with Marine Harvest has been a long-time client of mine. Dale has probably the most rigorous environmental monitoring program that exists privately anywhere in the world. He has taken significant actions on a number of cases with significant economic implications for his company, based on recommendations that I have made — to close farms, to shut down operations at farms, to get farms moved.

I consider myself independent. I'm a retired Navy fighter pilot, and I'm used to being shot at. I'm old enough to stand my ground, and I'm absolutely dedicated to sustainable use of our resources. I consider what I do to be totally independent of my clients. If they don't like what I say, be they government or industry, they can go find somebody else.

[1320]

R. Cantelon (Deputy Chair): Well, I'm not sure if the fog of uncertainty is lifting or getting denser in the room. On the one hand, we hear from Dr. Brooks that as many as five billion pinks may have been released. Earlier Dr. Morton had indicated — please correct me if I misstate you — that one louse per hundred would be a fatal level of infestation in a farm.

My question is to Martin Krkošek. If I understand you correctly, coming back to my stats 101, we now have a range of probabilities of mortality — if a fish is infected going by — that is somewhere between 9 percent and 95 percent, depending on seasonal and proximity and so forth. I guess what we really need to understand better is: what's the survival rate? We've heard in Dr. Beamish's paper, and quoted by Dr. Morton, that in one instance it was as high as 34 percent, which is unusually and extremely high.

Does your study give any indication, Martin, specifically, of what percentage of those five billion — or however many there are — are infected? What percentage gets infected going by? We know that if they're infected, the fatality is between 9 and 95 percent, but we don't know how many fish get infected. Can you comment on that.

M. Krkošek: Sure.

R. Cantelon (Deputy Chair): If I recall, it's one probability times the other probability. Is that right?

M. Krkošek: Sure. It could be that simple. We do have the complete distribution of sea lice on the juvenile salmon migrating out. We know what proportion of these out-migrating cohorts have zero lice, we know how many have one louse, and we know how many have two lice, and so on. From that, we make those calculations on the range and mortality. It includes those fish that are not infected as well.

R. Cantelon (Deputy Chair): But do you know what percentage of the total population gets infected? Can you say that?

M. Krkošek: Of the total population migrating out of the migration corridors….

R. Cantelon (Deputy Chair): Yes, because that would seem to be key to survivability, which seems to contradict "an awful lot survived."

M. Krkošek: We know for the entire populations migrating out these migration corridors that we're studying. The example of high marine survival — 35 percent — happened to a different cohort of salmon than the cohort to salmon that we were studying and estimated these high mortalities.

When there was the occurrence of the 34-percent marine survival, the exceptionally high marine survival, that corresponded to a year when this migration route was fallowed. The abundance of sea lice was very low, and the sea lice that were there were primarily *Caligus clemensi*, as opposed to the *Lepeophtheirus*. I think there will be fairly general agreement that the *Caligus* is far less pathogenic to these fish than the Leps.

R. Cantelon (Deputy Chair): Well, I also know that only four of 20 farms were fallowed, and it's questionable how much effect it would have in the total bio-

mass. But my question is: do you know what percentage, specifically, of the total five billion gets infected? How many escape — go by the farms, go by this gauntlet there — and actually make it out into the ocean?

M. Krkošek: In order to know that, we'd have to study every possible migration route out of the Broughton, and we haven't done that.

R. Cantelon (Deputy Chair): Okay, so you don't know that part of the equation.

M. Krkošek: No, we don't.

R. Austin (Chair): Thank you very much. At this time we're going to recess the committee for half an hour to have lunch, and then we'll see you back in. We would ask that the members of the panel please join us and have some lunch.

The committee recessed from 1:24 p.m. to 1:59 p.m.

[R. Austin in the chair.]

R. Austin (Chair): Welcome back. I'd like to call the meeting back to order. If panel members and members of the committee can find their seats, then we can continue.

[1400]

Our third question…. I'm just going to ask the broad question because you all see in front of you what specifics we'd like you to speak to. You can speak to other parts of it, but the broad question three is: can wild and farmed salmon coexist in the Broughton Archipelago? I'd like panel members to give their view on that, starting with Ken.

K. Brooks: The first thing I'd like to say — and I'm sure Dick Beamish will expound on this — is that if you look at the numbers of pink salmon fry that leave their natal streams every year, it's obvious to me that…. The numbers of pink salmon fry that re-enter the Broughton Archipelago…. As we've heard numerous people testify, early growth is really important to these fish to survive. It's critical. Are there migration routes through the Broughton that we could make safe for these fry? My answer to that question is that it's unlikely from a basic ecological point of view.

The reason I say this is: consider yourself one of…. Even in a normal year when there are perhaps three billion fry coming out of these rivers following in the footsteps of your predecessors who've eaten everything in front of you, would you continue down the same path? Or would you start to perfuse throughout the entire archipelago looking for food? You're a ravenous young guy, and you need food to survive.

My sense from just basic ecological considerations is that it's unlikely that there are truly distinct migration patterns in the archipelago, and that if there are subtle migration patterns in the archipelago, those tend to disintegrate during years of high returns and high emergence of fry.

I've already talked about the mussel studies that we did — the very slow growth compared to other areas in the Pacific Northwest, suggesting that phytoplankton are a limiting resource in the archipelago.

I guess, in summary, based on all of the evidence that I have seen, I see no reason to assume that Atlantic salmon farms and pink and chum salmon fry, or coho and chinook, cannot coexist in the Broughton Archipelago. Do they affect each other? Probably — in either subtle or less subtle ways. The task for us, I think, is to understand those interactions better and to learn to manage both systems in a way that optimizes the productivity of that archipelago.

I've heard no one discuss the management of the Glendale spawning channel as an important factor in the survival and condition of these fry. Obviously, based on a long history of studies, you can exceed the carrying capacity of a marine system. The Glendale spawning channel, in my estimation, is one factor that needs to be managed.

Dick Beamish has told me that a higher and higher proportion of all of the pink salmon in the Broughton Archipelago are coming from the Glendale channel each year. So the fish spawned in that channel are obviously consuming more and more of the resources, perhaps — I don't really know — to the detriment of other smaller systems in the archipelago.

[1405]

We talked about an integrated pest management system. I would like to see us expand that to an ecological management system in which we look at all of the factors that affect these populations, including salmon farms and other anthropogenic influences on the system, like these spawning channels.

D. Stucchi: I will comment briefly on this one, even though some of the aspects of specific questions A and B are…. I would leave it to others to comment on.

I think salmon farms can coexist in the Broughton. We've seen last week at some of the briefings that were presented that there are concerns that we can see declines in recent years in the pink juvenile runs in the Broughton. But the variations, as we've also seen, are quite large for this particular species, and they have a complicated, multistage life history, of which the early estuarine survival is only one part. The ocean survival is another important component.

The farms are a known source of lice. There is consensus there. We see increased infestations near farms and away from farms, as well, in the data collected by the researchers working there, though the actual impact of those lice infestations on the farms seems to be unclear. We have opposing experiments and information there, and we need to get at the causes for those differences to understand the impact. Ultimately, we want to know what the effects of these lice infestations are on the production of the pink salmon and chum salmon runs in this particular region.

Just to reiterate, I do think they can coexist, but we should be vigilant and keep watching and trying to understand the infection and disease transmission processes as well as the impact on the production of the pink salmon in the area.

R. Beamish: I've already spoken about the coexistence, and I think the answer is yes. The evidence for that is what happened in 2003-2004, but it's also what happened in the 1990s. Again, you've heard a lot about that. The abundance of salmon — both lines, by the way…. It's something that hasn't been mentioned, and I don't know whether…. I wasn't here last week. Has someone explained the odd and even year line?

R. Austin (Chair): Yeah, and we saw graphs.

R. Beamish: Remember that one is increasing, and the other isn't. They both go under the same ocean, essentially, but just different-numbered years. So there's something going on.

Okay, so the answer is yes. In 2006, again briefly, people have mentioned that the levels of sea lice that the various investigators observed on juvenile pink and chum were, I think, the lowest or close to 2003 levels. So yes is the answer to the first one.

The question about numbers of adult salmon, the abundance of wild juvenile pink and chum. We were funded this year by the Pacific Salmon Forum to do a survey. We have been doing what we call swept-volume surveys of salmon in the Strait of Georgia for ten years, and we make routine abundance estimates for other studies. Methodologies are published, and the methodology that we use is approved by the salmon forum.

Here are the abundance estimates. I think you're the first to get them. In late June or early July of 2006 we estimated…. In July in the Broughton area there were 634,000 pink; in Queen Charlotte Strait, just outside of the Broughton area, there were 1.818 million. In the Broughton area in 2006 there were 487,000 chum and 1.821 million chum.

[1410]

These numbers are not large, but you have some idea of what is coming back. You've seen the escapements. We're looking at a little over half a million juvenile pink salmon in the Broughton area in basically early July. Clearly, there are still salmon there in what would be a reasonable abundance.

S. Jones: I also agree that wild and farmed salmon can coexist. I'd go so far as to suggest that they have been coexisting for 15 or 20 years since salmon aquaculture was first introduced into the region.

Clearly, what we recognize from the discussion this morning is that whether they have or have not been coexisting, there's an awful lot we still need to learn in terms of understanding what the biological, oceanographic and other factors are that drive survival of the juvenile pink and chum salmon. We still really don't understand this. We recognize that there are sea lice infestations on these fish, but in terms of understanding the impacts of these…. It's quite clear that there's not enough information. The data are still very early and inconclusive.

What I would like to point out, though, is that from our surveillance data, if you look at levels of lice…. I tried to make the point earlier today that we've seen in juvenile pink and chum populations this tremendous year-to-year variation, despite a fairly consistent biomass of farmed salmon in the archipelago.

For example, approximately 75 percent of the pink and chum salmon were not infected in 2003, 30 percent were not infected in 2004, and approximately 65 percent to 70 percent were not infected in 2005. This year we haven't completed our analysis, but it looks as though about 80 percent of the juvenile pink and chum salmon do not have sea lice on them.

Of course, there are spatial and temporal fluctuations in that data, but it does indicate there are these very significant year-to-year fluctuations that we need to understand. We don't yet understand what is behind these. Farmed salmon may play a role, but we recognize that the farmed-salmon industry has evolved, as well, over the last few years. They've evolved management practices that enhance their disease surveillance capability. They've adopted more stringent practices for diagnosing and treating, for example, sea lice. They vaccinate their fish. So there are processes in place, management practices, that we could suggest are swinging the balance — at least, if there was an impact, neutralizing — away from that impact.

What we were really lacking is an overall ecosystem sense of how all of these processes link together. So while I say that the farmed and wild salmon can and do coexist in the Broughton Archipelago, we really don't understand why that is. This is where we need to address it and focus our questions.

M. Krkošek: Can wild and farmed salmon coexist? I honestly don't think we have enough information yet to answer this question. From the perspective of sea lice, yes, we know that sea lice can spread from farmed salmon to wild salmon. Yes, they can be a major source of mortality. We also know that treatment and fallowing can reduce sea lice numbers. We don't know if that is sufficient to protect these juvenile fish.

Then there are all kinds of other diseases that no one has a handle on at all. No one is studying them. We don't know what these interactions are. It's really difficult to assess how these interactions can scale up to affect populations. What are the returns of adults? How are these influenced by these interactions? Is it enough to just coexist? How much of a depression of the wild salmon stocks are we willing to tolerate?

There are some populations in the Broughton that are severely depressed, and I think we've seen pretty convincing evidence that this is due to disease interactions with farmed salmon. Do we need to see some of these populations be driven to extinction or extirpation in order to change the way we're managing these farms in the Broughton? I think there are too many out-

standing questions yet to really point to a definitive answer one way or the other on this question.

[1415]

R. Routledge: I'd like to put up a couple of graphs here, if I could.

S. Jones: Excuse me, Mr. Chair. I also have to leave at quarter to three.

R. Austin (Chair): Okay.

R. Routledge: I agree with Marty that mere coexistence isn't really good enough. Here's my version of the question: can wild populations thrive in their traditional abundance without substantial controls on farm-origin lice levels? My answer to that question is no.

I want to show you a really rough graph. On the horizontal axis is going to be lice abundance on outmigrating pink salmon. Very rough estimates — I'm not going to verify they're very accurate. On the vertical axis I'm going to show you an index of marine survival. It looks something like that.

I'm sure people will disagree about the location of those points, but there is that one anomalous year in 2003. And 2005 might come in there somewhere. Now, what does that mean?

Well, here's another graph which I think might help explain it. This is one I constructed for Rivers Inlet. It looks very similar. Lots more points in the second graph, but the shape is generally the same. What that shows is that for Rivers Inlet juvenile sockeye, you don't get good marine survival when you have a lot of water flowing down the Wannock River in early spring.

If you don't have a lot of water flowing down the river, sometimes you get really good survival, and sometimes you don't. I take that as indicating that sea lice can kill juvenile pink and chum salmon. I don't think there is any real doubt in my mind about that. So do lots of other things.

Abundant sea lice in juveniles means you get poor returns. No sea lice in juveniles means that maybe you get good returns or maybe you don't. If we want to give the fish a chance, we need to get better control on the lice levels.

A. Morton: Can farmed and wild salmon coexist? Probably, but I don't think they can in the Broughton. The entire Broughton watershed is a salmon production mechanism.

This is how the salmon migrate through the Broughton. They're coming from rivers. They're going down narrow channels. A number of rivers are coalescing together and forming larger migration routes.

In 1989 — I know I brought this up to you before — the province came around to the Broughton and asked fishermen and others where not to put the fish farms. Then they put them in exactly the spots where the fishermen said: "Don't." All of these red areas, painted red by the province, were not supposed to have fish farms, and there they are. Those are the ones that went into the red zones. These are the ones that went into the areas that were not red.

This absolutely guaranteed social and biological conflict. Is government good for their word or not? These farms should be removed.

While it is unpopular to say, salmon farms are feedlots — high-density livestock fed as rapidly as possible. By placing these feedlots on every artery of the wild salmon migration route — there are the feedlots, and here come the salmon — you absolutely guarantee exposure to the young wild fish from the farms, and vice versa.

After what we have learned about the avian flu virus, would we do this with wild migratory birds and battery chickens? Absolutely not. Everybody was forced to keep their chickens inside.

[1420]

I took the tags that had been collected from wild fish caught in the Broughton, and here is where they came from. They came from Washington State, the interior of B.C. and Bella Coola. These were chinook and chum salmon that have come from these rivers, gone to the Broughton and presumably gone back to their rivers. So they're now carrying whatever happened in the Broughton to a much larger area of the coast.

Farmed salmon need to be quarantined. Heritage Salmon knows this: "Effective immediately there is a Broughton area quarantine. Treat your site as if it is positive for a highly infectious disease."

This is a study by Sonja Saksida. She found that a few salmon farms got infected with IHN. These yellow lines are for the packing boat carrying farmed smolts first to the Broughton and then to Bella Bella. Wherever these packers went, IHN started to infect farms — the Port Hardy area, the Broughton area. There was only one farm in Bella Bella. That farm got infected.

This shows you that exposing farmed fish to the effluent from these farms brings on disease. These are fish. We know what happened to them. We don't know what happens to wild fish. As was pointed out, wild fish die.

This is a picture of part of a body of a small salmon near Campbell River. We know they're getting sea lice.

Here's the location of farms. This is where government has put farms on our coast. This is where the most wild salmon in all of British Columbia go through. You've got your mainland rivers. You've got your Fraser stocks. You've got east coast Vancouver Island rivers. We're talking chum, chinook and sockeye.

They're all running through. They're being filtered through these high-density clusters of farms. You could not site these farms better if you wanted to make sure you were exposing wild fish to what's on the farm. Again, would we do this with chickens? No.

There's the disease issue. Then there's the drug issue. Last Friday my 71-year-old neighbour stopped by the chemical barrel in his speedboat, found near a farm. It's called Parasite-S. There's a skull and crossbones on it. The barrel was open. It says it can cause liver damage, brain damage, cancer. It's applied by pouring into the water. Does anyone think farm water contaminated with this is going to stay on the farm?

I know this shot is below the belt, but this is a beach that children play on, maybe not at this time of year. Does the public know what's in this barrel?

Government is really going to want these flatfish diseases associated with Broughton salmon farms to be non-lethal to humans. I'm sending it out to labs all over the world, and some of them have suggested that it's a flesh-eating bacterium.

Biologically, socially, responsibly, feedlots do not belong in net pens along the entirety of our coast.

You ask about migration patterns in the Broughton, and this is basically what happens. That is the area that was fallowed, in the yellow. It was a great success. I was happy to hear Dick Beamish say: "Remove those four farms." It wasn't actually four farms. It was 11 farms that were fallowed.

Here is associated impact. One is the chum salmon, on the right. On the left is the pink salmon. All year.

DFO say they've increased monitoring of pink and chum returns in the Broughton. That means these numbers over here had far more effort going into looking for every last pink salmon that went into a river, as opposed to the numbers to the left. The numbers to the left also supported large commercial fisheries, which aren't recorded there.

These numbers on the right are everybody that came back. Those numbers are low. They're remaining low, except for 2004 when the fish farms were removed from that yellow route.

R. Austin (Chair): Thank you. I'm going to open the floor to questions and ask that members ask one question, at least initially anyway.

S. Fraser: I've got a question. On some of the farms in Clayoquot Sound we've seen problems with predators. I know that's an issue and a challenge for the fish farms to deal with. What about wild salmon? What about young pink or chum migrating out? Are they attracted, potentially, to fish farms? Is that an issue?

Ken mentioned that the migration routes were hard to nail down. Alex, you showed some pretty specific migration routes. But outside the natural migration routes, are the farms themselves an attractant to potentially increase that level of contact?

[1425]

A. Morton: I have personally witnessed, like I said, large groups of pink salmon stalling around the Humphrey Rock salmon farm. I've also seen them stall around the Glacier Falls farm for long periods of time. I don't know if those fish naturally were there, but the little finds of food that are coming out of that farm I would say almost certainly would attract these fish.

I've also seen predation of farmed salmon on wild fish. I've seen them eat herring while I was standing there watching a pen of fish this summer at the Midsummer Island farm.

When you go to these fish farms, quite often in the spring you'll see lots of little fry outside the pens but none inside the pens. I think they got eaten. I think the farms attract the wild fish, and I think they also get eaten.

M. Krkošek: One possible mechanism that would attract the juvenile fish, and other fish as well, into the fish farms is that some of these farms have lights on at night. Everyone knows that if you shine a light into the water, it will attract fish. These are big footlights.

R. Beamish: I think the answer is that we probably just haven't done those studies. You're hearing some speculations. If that's an important issue, it's fairly straightforward, including just looking at the stomach contents of the pink salmon and seeing what's in them. We do some of that, but we don't look it at enough to say anything definitive at this time.

S. Fraser: Just to finish that one question. We've got a consensus that in the case of fish farms — I'm not talking about other diseases, but just sea lice — there is potential for a negative effect on the wild. Obviously, there are ways to mitigate that — SLICE being one. But obviously, having less contact is another. That's why fallowing is done. And we don't know? Officially, no one knows? No one has done any work on whether or not we are attracting wild to the potential contact that we want to prevent. Is that correct?

R. Beamish: Yeah, I think it's fair to say that we haven't done that. Our group has done a little bit of that. I don't think we've done it well enough to answer. My speculation is: not really, because the juvenile pink and chum are competing heavily on copepod nauplii. Their inherent behaviour is for certain types of food. But again, that's just speculation.

Let me just correct…. Alex said that it was 11 fallowed farms. It's not. It's four.

K. Brooks: I was just going to refer, Mr. Fraser, to the study by Ed Black that was done back in the '90s, I think, in which he and several other authors examined this specific issue and came to the conclusion that farmed salmon were not consuming significant quantities of any kind of wild prey. There are fish that are frequently observed in association with salmon farms. One is this little side-striped shiner. Another is…. It escapes me right now, but there are fish associated with the pen.

You heard some anecdotal information. I can give you another instance, in which we were working at a farm in Rich Passage and saw a huge bloom of mycids. Herring were feeding on them intensively. I spent a couple of hours watching the behaviour of these fish, and the herring would feed on the mycids right up to the net pen but did not go in the net pen. That's anecdotal evidence. It's not the result of any kind of scientific study. It's just an observation.

The point I want to make goes back to Ed Black's study. There are so many issues that can be brought up with respect to salmon farming and the environmental hazards or costs associated with that. Science typically proceeds by examining an issue in some superficial

way, and if it appears that there is a problem, then science moves forward to more intensively address that issue.

[1430]

Science does not spend enormous amounts of time and money addressing issues that don't appear to be important, and based on the evidence that we have, it does not appear that cultured salmon consumption of wild prey of any kind is a problem.

G. Coons: I just want to get back into the coexistence of our wild stocks and aquaculture and, basically, how it relates to the concerns about the conflicting mandate of DFO. The Auditor General has, at least in four instances, had a concern with that.

I had a chance to go through the DFO book that we got the other day, and I found this interesting. I just want to comment at the end from some people about…. The DFO strategic plan for 2005-2010 ensures the wild stock has a high priority. But it also sets an objective to "undertake comprehensive action to ensure the safety and sustainability of the aquaculture industry and respond to public interest in this area." It also, within this context, says: "Risks associated with salmon farming will be treated equally to other users in impacts on wild Pacific salmon."

I'm just wondering if in the management system that we're doing through DFO and through the scientists, because DFO management is underpinned by the science from its experts and by the state of knowledge…. Before that, in the state of knowledge here, I see 70 to 80 knowledge gaps and research areas and lots of concerns. I'm just wondering: do you think DFO's direction from the top is undermining the discussion that we're doing right now?

R. Beamish: Well, since I've got 35 years in it, I should be able to answer that — right?

No, I don't think so. I actually sit on a board called the science management board, and I'm honestly totally convinced that at the highest levels in DFO, we're dealing with this issue — aquaculture and salmon farming — in the same way as we would deal with any other management issue. There are always complex issues.

You have to understand as much as you can about the dynamics of the situation, and then you manage, ensuring that you have an ongoing program to improve your understanding. It's what we do when we fish. You all know that we kill lots of fish when we go fishing. You'll probably eat some fish this weekend. Well, it had to come from somewhere.

There are a lot of uncertainties in fisheries management, and incrementally we try to understand what the dynamics are, but we have a mandate to manage. You said "the highest levels." At the highest levels in DFO there is a strong commitment to manage an aquaculture industry.

I think Riddell told you that 50 percent of our seafood that we're now eating around the world is coming from aquaculture, and it's only going to be another ten or so years…. Most of us don't go out on the weekend and buy wild meat. You're going to see major changes in the seafood industry, and aquaculture is where we're going to get most of our seafood in the future.

B.C. is perfectly positioned to benefit from a strong aquaculture industry, so let's get on with it. If there are problems, let's identify them, and let's manage them.

R. Austin (Chair): Anyone else want to make comment on that?

R. Routledge: When I was on the Pacific Fisheries Resource Conservation Council, DFO produced a wild salmon policy. It was a very good policy developed by some biologists at the Pacific Biological Station. It went off to Ottawa, and it came back totally emasculated.

I raised a stink. Some other people did too. It went through several iterations over several years. If you read the policy now, by itself it does not commit DFO to anything of any real consequence as far as I can see.

There remain good, dedicated people at the biological station and elsewhere who are trying to make that policy work, but I would say they're not getting the kind of support from senior levels that they need.

R. Cantelon (Deputy Chair): Dr. Morton, you indicated that the only answer is complete separation, and I presume it's only in that context that you would see farms coexisting — a different type of farm. Am I presuming too much, or is that the position that you're advocating?

[1435]

A. Morton: I think you have to separate these large farm salmon populations from our small wild fish. I cannot personally say where else these farms could go on this coast, because I haven't studied the rest of the coast. But I know that if you put them into closed containment, the salmon farms would benefit. They wouldn't have parasites, they wouldn't have seal kills, and they wouldn't have breakups. They would have permanent jobs. The communities that want these farms could have these farms right in their front yard. People could go home at night. They could be marketing wild salmon in the summer and farmed fish in the winter. British Columbia could benefit enormously from it.

The way I see it right now is that we're going to have only one salmon in the Broughton, and it's going to be farm salmon. They have to be separated. That is a simple and biological truth, as far as I can see in the work that I have done and the other scientists in this room have done in the Broughton — all of it.

Even Dick Beamish's work has shown that when you remove those farms, the wild salmon benefit. He said earlier today that if those four farms caused the number of sea lice to go down, move 'em. I think anybody comes to that conclusion when faced with the facts. I think separation is required, yeah.

R. Cantelon (Deputy Chair): Just to clarify that, you said there won't be any kind of fish except farmed

salmon in the Broughton if we carry on. Am I to infer that it'll wipe out all the other fish, then?

A. Morton: It's going to wipe out the other salmon. The steelhead are gone, the chinook are in freefall, and the coho are doing poorly. The chum and pinks only respond when you remove farms. It's a very serious situation or I wouldn't be devoting my life to it.

J. Yap: In your presentation, Alexandra, you had some photos towards the end. One of them, you said, was a…. But that's not the one I'm thinking of. It's the one with the fish that had very ugly growths on them. You mentioned in passing that you collect these fish and send them to labs around the world. Have you had any feedback on these specimens? Do you have anything to report on what those represent?

A. Morton: No. In general, it's very hard for me to get diseased fish tested. No lab in Canada will, at this moment in time, accept samples from me. So I send them to Washington State and elsewhere, and now I'm working with a scientist in Mississippi who feels free to work on this.

Every sample I've sent out, they say that it's rotten. But I'm taking this from fish that have been dead mere seconds. The idea of a flesh-eating bacteria has come from these labs. They can't pin it down. They need a live fish. I can't afford a disease scientist to come and work in the Broughton, but it is seriously needed. With all due respect, someone outside of the Department of Fisheries and Oceans is needed to come and take a look at what's going on in there. The commercial fishermen are handling these fish, and they just call it farm disease. They don't know what it is, but it's around the farms.

J. Yap: At this point, you have no evidence that these unusual specimens have anything to do with fish farms specifically.

A. Morton: Oh, but I do, because it's the same idea as the sea lice. When you get near a farm, you get these. As soon as the fishermen are dragging farther from farms, the sole look beautiful. They look perfect.

J. Yap: You have some correlation, but there's no lab proof or scientific research that's proven.

A. Morton: Correct.

G. Robertson: Just a general question around coexistence. Earlier there was a bit of back-and-forth around the appropriate distance away from salmon streams. I think the sense here was that a kilometre is what our standard is here, but we went from 500 metres to five kilometres in the exchange.

I think, Mr. Brooks, you described it as the necessity to locate farms away from the salmon streams to protect those wild stocks. What is that buffer zone that's required, and is it in fact possible, as we've seen in the PowerPoint presentations, given the extent of migratory routes and how much of this coast is in fact migratory route with vulnerable young fish?

[1440]

In terms of a precautionary approach or an approach that best guarantees that we have healthier wild populations of pink and chum, I'd be interested in hearing distance from the mouths of salmon-bearing streams — whether that one kilometre that's entrenched right now does make sense or whether in fact we should be further out. And if closed containment is an alternative, might that allow for those farms to be in fact closer to the salmon streams?

K. Brooks: That's a convoluted question. One, we're talking about moving salmon farms to areas of low salinity when, as you can see from the discussion here today, there's no agreement that salmon farms are making a contribution of X, Y or Z to the sea lice levels in the archipelago. So you're asking for people to take action when there's no clear need for that action.

Two, with respect to migration routes, I'm unaware of any rigorous study which has addressed that problem. Fundamental to understanding how siting of salmon farms in the archipelago relates to the distribution of fry in the archipelago, you have to achieve a better understanding of where the fry are going.

In my personal opinion, I don't think government wants to take actions willy-nilly. You want your actions to be the result of careful deliberation and reasonably clear evidence demonstrating a need for that action. At this point in time, a comment that I made to John Fraser was that without that specific information regarding migration routes, you may move farms from here to here based on someone's perception of where the migration routes are. And you may find that your actions were actually contrary to your goals and that you've actually exacerbated the problem, not mitigated the problem.

Whatever you propose, I would strongly recommend that it be based on good, sound science. Unfortunately for you folks, that means you're going to have to interpret very different perceptions of what the science is saying. I don't envy you that task.

A. Morton: Look, unless the salmon are going over the mountains, they're going by salmon farms. I've had this migration discussion now for five years. If you've got a long, narrow channel and fish are dumping into it and there are salmon farms in the channel, it's a migration route, and they're going by the farms. There's no way out of the Broughton right now without passing several salmon farms. Just last spring the fate was sealed with that Grieg farm put into Clio Channel where Dario had some of his drifters head for.

It's funny. It's almost hilarious. Dr. Beamish's paper on this extraordinary survival of the pink salmon…. I was one of the reviewers. It was a journal in Denmark. He kept saying there was no fallow, and I kept saying there was a fallow. Finally, the reviewer said: "Look, you guys have got to talk. You've got to hash this out." Now we're discussing whether there were 11 farms fallowed or four farms fallowed.

The province put out a press release on this fallowing. There were 11 farms that were empty of fish. There were only four that were even thinking of putting fish in, which is where Dick gets his number. In fact, there was only one farm that actually removed fish. So it was 11 farms that were fallowed. It's on their website. I can send it to you.

In terms of these migration routes, I cannot believe that we can look at that map of the Broughton and say that it's debatable whether these fish are going by farms or not.

[1445]

G. Robertson: If I can, maybe a little more pointed question, then, in terms of coexistence. I think everyone that we've dealt with over the last years desires to see a better outcome here. As far as coexistence is concerned, does it make sense for government to continue approving farms and increasing density and number of farm fish when we don't know these answers, when we don't know conclusively whether there are impacts and whether we're in fact compromising the wild stocks?

R. Beamish: Mr. Chair, I am sorry to interrupt, but I have to go.

We're starting to ask questions that are outside of the questions that you presented to us, which are fine. That's a reasonable question, but there are lots of other questions. If we're going to open it up to all kinds of questions, that would be good too. Maybe you want to meet again or something.

R. Austin (Chair): This committee will discuss whether we want to meet again for the science panel. I do hear what you're saying, but I think it's a question that has just arisen from the general debate on this question.

Does anyone else have any comment to make on that?

R. Routledge: I want to answer that question. Absolutely not. It does not make sense to expand fish farming, especially up into areas of the coast that don't already have farms. We really can't handle the situation in the Broughton effectively yet. It looks like maybe one year we found things worked quite well. We need to learn from that and try to understand how we can avoid these impacts.

We've got to watch out very carefully in the places — I've said this before — on the central coast where we have small, vulnerable sockeye stocks and where we might be losing genetic information.

S. Jones: I also have to leave, but I'd just like to say what I said earlier regarding the years in which we took no obvious action. That was in 2005 and 2006. We've heard arguments that fallowing in 2003 contributed to lower lice levels in comparison with 2004. Yet when we took no fallowing action in 2005 and this year, 2006, we've seen lice levels below what we saw in 2003.

I really think we need to look hard at what is the evidence that says conclusively that salmon farms and nothing else are driving sea lice levels on juvenile pink and chum salmon in the Broughton Archipelago. The abundance data that we've got for last year and this year, in my mind, strongly suggest that in the absence of fallowing, there are other factors — probably environmental, perhaps related to the condition or numbers of juvenile salmon in the area.

What this gets to is the need for an objective, rational, scientific-based approach to our decision-making. It's quite clear in my mind that there is still tremendous uncertainty. It's not sufficient to say that salmon farms are the contributing factor to sea lice infestations in the Broughton Archipelago. I think the data we have now — granted, not all of it is published yet — do indicate that we have to consider alternative explanations.

I'm afraid I've got to go.

R. Austin (Chair): Well, I'd like to thank both of you for coming here today.

We're going to move on to the next question. I'd like you to comment on ways that would mitigate against the effects of the organic waste discharges from open-net-cage aquaculture. We're looking here at far-field and ecosystem effects.

A. Morton: I believe there are ways to mitigate the effects of organic waste discharge from open-net aquaculture. Closed containment. A recent study on the effects of fish farms on areas of high current demonstrated major impacts on the benthos even in strongly tidal areas. This is a recent paper published in 2006, and I can certainly make it available.

[1450]

Salmon farms drop tons of food into the water daily. Society has matured to the point where we know that it does not simply disappear. It's going to travel, suspended in the water column, until a widening of the channel or something similar causes the current to slacken, and then it will fall. Gravity is in effect underwater. If tons go into farmed fish, tons come out.

Each farm is going to have a flood-tide dumpsite and an ebb-tide dumpsite. The reason the farmers don't want to deal with what comes out of their fish is because there's a lot of it. Just because they don't want to deal with their waste products, should they simply be allowed to throw it overboard?

R. Routledge: I want to give this a sort of broader perspective, if I could. I'm not going to show graphs. I'm going to show pictures this time. First of all, this is a very complex system. Dario has made that point very effectively with this model he's constructed.

I want to show another complex physical system. These are little water crowns that you get if you get a fancy little high-tech water pistol and drive that piston up and down. Vary the speed with which you make that piston go up and down, and you get different things happening. In the middle there you see that you get that nice little water crown.

I want you to focus on the upper right-hand corner. That's where people have tried to model things, and there are some model predictions. A little hard to see,

but I think you can see that they did a pretty good job. I want to point out that that happened in a certain order. It was first an observation of some unpredicted phenomenon followed by some theorizing, experimentation and modelling.

There was a limited capacity for prediction, and I stress the word "limited" — didn't predict this and couldn't predict the precise form of that fancy little structure. If you turn it on its side, that's what the model would have predicted. It only predicted the top part of that picture. Here's what in fact happens.

We've made these sorts of mistakes all over the place. Here's a classic quote from some poor fellow who looks like such a doofus now, thinking that if you just spray DDT early in the spring, you wouldn't have a problem, because the birds died later in the spring. Lots of other surprises: CFCs, persistent organic pollutants in the Arctic, and so on.

We need to be humble. This is a very complex ecosystem in the world here, of course. You might think that little pink salmon with sea lice on them are simpler, but if you look inside the water and look at the phytoplankton and zooplankton, you'll find all sorts of amazing little critters. Here's a little guy who builds a plankton net out of mucus, and he filters water to feed on plankton. Of course, there are all sorts of species in these ecosystems. In order to predict what's going to happen…. It's just impossible.

I would argue that we need to be humble; we need to be cautious. And I'd like to echo what I think were Dario's words: we need to be vigilant.

M. Krkošek: I'll just be really brief. This isn't my area of expertise, but I'd be of the opinion that, like most industries, they should be responsible for controlling and treating their waste products before releasing them into the environment.

D. Stucchi: I don't have a slide show, but I'll just go through a progression of ideas and points. I think what Rick Routledge showed earlier in his three steps to try to encapsulate the process of how we gain understanding…. I think one of the first things for a far-field and ecosystem fix is that we need to identify and describe the effect: what's happening, where it's happening, for how long, the organisms involved — those kinds of details. You need an observational program.

Part of that also includes the local community in the area, since baseline data is often important in trying to establish changes over time. If you don't have that information, it's difficult to establish if you don't know what it was like before. To that aspect, traditional knowledge of the community — first nations, for example, who live in the areas — is a good way of getting at some of that baseline information.

[1455]

Once you see something is going on, some effect taking place on a larger scale in a far-field sense, you need to establish some investigative program to try to get a better handle on what is causing it. You need a more focused scientific approach — a hypothesis to test, for example — to try to establish these cause-and-effect relationships.

There are many tools that you can bring to bear to address those kinds of issues. Some of them have been discussed today. We discussed some of them last week with some of the modelling tools — chemical tracers, monitoring, for example.

Once again, this is a far-field ecosystem approach. So it's a large scale, and no single agency or group can do it by themselves. It really requires a collaborative and cooperative effort of the communities and agencies responsible for the certain parts of the resource.

Mitigation measures. There are a whole range of mitigation measures one could bring to bear on the problem, but I think fundamental to that is understanding the cause and effect. To proceed on some kind of mitigation measure without actually having a good handle on what the mechanisms are that bring about this effect could be very wasteful and harmful.

There are a range of mitigation measures. I can list them all out, from one extreme of closed containment, where you remove the farms completely from the system, to reductions in farms, to somehow trying to gauge or underpin a carrying capacity or a similar capacity for the larger ecosystem. Production limits is another way of going at that.

More innovative approaches, like polyculture, where you put other organisms like vegetation or bivalves around the farm to mitigate some of the waste…. That's been suggested, and I think it's actually happening on the east coast. I think there's a local farm here on this coast that will soon embark on that kind of polyculture technique. That's a novel approach and a different approach to the problem.

Siting and, of course, fallowing are other ones, and best management practices. You want to make sure an industry is doing things as well as they possibly can in operating their particular activity — in this case, finfish farms.

Those are general comments. I just wanted to end off with a few more characteristics of this far-field ecosystem effect. They need to be understood. I've touched upon several of them already, but just to re-emphasize.

One is that you need baseline information, and the traditional ecological knowledge of the community is important to establishing that baseline.

The nature of the complexity of this problem. Last week we talked about near-field impacts of waste from farms — 100 metres or so. Now we're talking ecosystems, which are ten times larger than that — well, more than ten times; almost 100 times larger. When you talk about an area, you square that number. So the scope is much, much larger, more complex, more costly to try to understand and beyond the capacity of any single agency or group of people. It really speaks to a coordinated and collaborative effort to tackle those kinds of issues.

One of the other complicating factors, too, is that once you move to these larger scales, there are other sources of impact in that ecosystem — other industries and other natural processes that may bring to bear. Trying to unravel those becomes much more compli-

cated in a large system like that. Because of its complexity, it requires a multidisciplinary approach.

We're really moving into a much more challenging area. The only way forward is to be more collaborative and cooperative.

K. Brooks: A couple of points. One, the comment was made before that industry hasn't been held accountable for understanding and managing organic waste associated with these farms. Nothing could be further from the truth. Industry has spent millions of dollars monitoring sediments in compliance with the province's finfish waste control regulation. MAFF has spent millions of dollars monitoring that.

[1500]

The database that I just finished analyzing contains 1,119 cases and 1,354 variables. It represents an enormous investment in understanding benthic effects. We can, at this point in time and in a very reasonable way, quantify those near-field effects. We know that they are real. We also know that depending on siting, we can either see an explosion of life under and around these farms or we can see significant reductions in the macrobenthic communities. As Dario just alluded to, far-field effects are very subtle, and they're very difficult either to measure and/or to assign a source to.

DFO had a workshop — I think it was here in Vancouver, wasn't it? — last February to look at far-field effects. It was a science guidance policy workshop, and I was one of five or six reviewers that were asked to come. Far-field effects was one of the topics of discussion. In general, very consistent with what Dario said, our conclusions were:

(1) Computer modelling is one of the best avenues for understanding far-field effects.

(2) You need to fully understand all of the inputs to a system that contribute to these far-field effects, and that requires very detailed, very expensive, very time-consuming and very lengthy mass balance studies in which you assess what all the inputs are to this system and what the relative proportion is of the total contributed by each system.

(3) Perhaps most importantly, far-field effects require long-term monitoring programs. There is no good evidence of far-field effects associated with salmon farming or with bed aquaculture.

There are suggestions — as, for instance, in L'Etang gulf in eastern Canada — that far-field effects may be causing a general eutrophication along with all the agricultural inputs, but they're just beginning to explore that. Far-field effects on this coast are of diminished importance because the most likely far-field effect that we will see is eutrophication with the addition of dissolved nutrients to the water column.

Because of upwelling off our coast, not all but most waters along the coast of the northeast Pacific are not nutrient-limited. They are replete with nutrients, particularly nitrogen, which is brought to the surface by a phenomenon called upwelling. So adding more nutrients to a system that already has more nutrients than the plants need does not cause eutrophication in the common sense — the proliferation of nuisance blooms of phytoplankton.

The thing that controls phytoplankton in the Pacific Northwest, in general — there are some nutrient-sensitive areas — is light. Phytoplankton are light-limited. In the Broughton Archipelago phytoplankton are limited because they are continually being circulated to depths below what's called the compensation depth, which is the depth where they're growing as fast as they're dying. That's what limits phytoplankton productivity in the Broughton Archipelago.

Far-field effects is one of those things that…. When aquaculture starts out, your primary concern with organic enrichment needs to be in the near field. I define the near field as that area with which you can make point-in-time estimates of an effect. As aquaculture expands and becomes more intense, then your focus needs to move from not only the near field but to the far field. Certainly, based on aquaculture activities in other parts of the world, we're nowhere near being at a density of farming that would suggest that you're going to see far-field effects in the Broughton Archipelago.

R. Austin (Chair): Thank you. I'll open the floor to a question.

[1505]

S. Fraser: This is a tough one. We've had this issue raised a number of times at some of our hearings — around far-field effects and the concern about what effect it might have. Of course, we're hearing that it is a daunting thing to even monitor just because of the sheer nature of it.

The cost is prohibitive. That plays into some of the criticism we've had of the industry in the sense that, basically, the aquaculture fish farms are using the public resource — the oceans — as a distribution-dispersion method.

We don't know the effects because they're pretty subtle and pretty hard to monitor. I didn't get an answer on that, and I don't think there is one, so it's a bit of an issue that I still think is left out there.

There is an issue that has come up in this conversation today, and it has been around the nutrient level in the Broughton and phytoplankton. I think it was Ken who mentioned this to be fairly low. I think it was in relation to a shellfish farm or something you mentioned. It wasn't the best location for it.

The Strait of Georgia, in general, is a high-nutrient area. I know that shellfish do well, generally, in a lot of areas, and this is part of that strait. There's already carrying capacity. We've already seen that there's a huge current flow here.

I can't understand this. Why is there a low phytoplankton level that would potentially be prohibitive for polyculture for shellfish? Why would that be occurring here? We've got traditional knowledge from first nations in the area, who say that in many ways this has always been a very profitable shellfish area historically for first nations. Why is that no longer the case? Why

do we have low phytoplankton? What causes that? Does anyone know?

K. Brooks: Again, the availability of light is what primarily controls phytoplankton, not in all areas — I'm not going to make an inclusive statement — but in most areas. The compensation depth, which is this depth I'm talking about where phytoplankton are not reproducing as quickly as they are dying…. Below the compensation depth, their respiration exceeds the production of new carbohydrates through photosynthesis. That's about five metres.

Where you have fast currents and a lot of turbulence in the water, the phytoplankton are continually driven down below that level. Where you see blooms is where you have — for instance, in Puget Sound — very still days with a week or two weeks of no wind and huge freshwater inputs, which create lenses that cause pycnoclines in the water that holds the phytoplankton up in the photic zone. They then multiply to create blooms. But throughout most of the area it is not nutrient limitation that drives phytoplankton production. It's the availability of light.

S. Fraser: Has there been a change, then? Because according to first nations with traditional knowledge that we've talked to, this has always been an area that has been quite productive in shellfish production. We've heard that that has diminished, and you've also said that there is limited phytoplankton. So was there a change historically from then to now? What happened? The light situation presumably hasn't changed.

K. Brooks: I can only tell you this. I spent five years studying and helping remote Aleut tribes in south central Alaska enhance their shellfish stocks using money from the *Exxon Valdez* trustees. Their shellfish stocks are all depleted as well. The primary reason we determined for that was, quite simply, overharvest. The shellfish growth rates are low, and the shellfish, as the stocks are depleted, don't regenerate nearly as quickly as they do, say, in Puget Sound or even in southern parts of Vancouver Island and British Columbia.

I can't tell you what the status of shellfish stocks historically was in the Broughton Archipelago or how they have changed in the last few years. What I can tell you is that in 1996 when we undertook the Arrow Pass study, we did that in cooperation with KTFC.

[1510]

One of the projects there was to look at clam growth and survival adjacent to the farms to raise mussels. This whole thing was supposed to end with a taste test to see if tribal elders could determine differences, could determine in a blind test where these various shellfish came from. We went out and spent two days with the dive team from KTFC first nations. There was only one place, which was at Arrow Pass, where we could find any shellfish within a kilometre of a salmon farm. So that's where we decided to set up our study.

The point being, again…. It comes back to a theme that keeps presenting itself here. There are lots of assertions of harm and effects associated with salmon aquaculture. I'm ⅛ Cherokee, so I'm a little bit sensitive to the intuitive way that Native Americans think. The only way the European part of my personality sees to proceed is to look at the effects, determine which are most like to occur and then go out and examine them in some detail to ascertain whether they are perceived effects or real effects. If they are real effects, then we find solutions to the problems that are causing those real effects.

M. Krkošek: Can I just comment briefly on the phytoplankton thing. I'm not so sure the Broughton has generally lower phytoplankton than other areas or if it's less productive. This is something that's come up based on one observation from one year of work. You really have to study this for many years and have much broader spatial coverage to say that the Broughton has less phytoplankton than other areas. In fact, if you look historically — Alex, you can speak more to this, I think — the Broughton used to support one of the highest densities of aboriginal peoples anywhere on this coast, which would suggest that this was traditionally a very productive area.

G. Coons: Again, when we come back to near-field, far-field…. I've been trying to grasp this for quite a while, ever since I've been reading about B.C.'s regulation on waste and the science advisory group's concern that it only dealt with near-field and they had concerns about far-field. Just recently in our state-of-knowledge reports — which, as DFO says, underpin the management decisions that regulate the industry — Hargreaves indicated that there's a need to determine sustainable levels of salmon aquaculture production within coastal regions, inlets and embayments where marine fish aquaculture is currently practised in Canada. And there are concerns about the impacts of antibiotics and resistance.

Also, Dario mentioned the impacts of eutrophication. It's up to kilometres if not tens of kilometres away, and that was in the CSAC article, which we didn't have in our package. He talked about it. It did say a management approach that does not consider potential large-scale eutrophication may be ignoring one of the most significant potential impacts of some marine fish culture operations.

I have concerns about that, but my question is…. Getting back again to state of the knowledge, the near-field effects that Wildish, Dowd, Sutherland and Levings did here…. They said that we need to devise new environmental monitoring methods. I just want to ask the committee: do you think that in British Columbia, on our Pacific coast, to protect the wild stocks and ensure sustainable aquaculture, we need to devise new environmental monitoring methods?

A. Morton: I would say yes, and one of those methods has to be transparency and availability of the in-

formation to the scientific community. I mean, it's fascinating to hear that Ken's doing all this analysis on what's falling to the bottom and what's going on there. I've never heard of it. I've never seen it. There are many things we don't have access to. We don't know how many fish are on the farms. We don't know what they're treated with. We don't know their disease histories. This limits the ability of non-government and non-industry scientists to be part of this debate and part of this discovery.

I would say one of the techniques that really needs to happen is availability of the data — what's going on inside of the farms — to the researchers that are stuck on the outside.

[1515]

K. Brooks: I have published probably half a dozen articles in the peer-reviewed literature describing the results of these studies. They're readily available to anyone who looks.

I was going to talk about this a little later, but since we're on the subject, I recently presented a paper — which I will leave with you; I don't expect that you will have the time to read the whole thing — at an FAO conference. The subject of this paper was a comparison. It was one of five papers presented at this conference. The subject was to compare the environmental costs associated with aquaculture with the environmental costs of other food-producing sectors. My task, since I raise beef cattle, was to compare the environmental costs of salmon aquaculture with the environmental costs of producing beef. Other people took on rice versus shrimp farming — those kinds of comparisons.

I think it's inappropriate and counterproductive to achieving sustainability to focus on eliminating or mitigating to some minuscule level the environmental costs associated with one activity and ignoring the environmental costs associated with other ways of producing food. The bottom line is that aquaculture is here and, in my opinion, will continue to expand and grow, because we have never demonstrated anywhere at any time an ability to effectively manage the harvest of wild stocks of fish. Everywhere we look, wild stocks of fish have been depleted, including here in British Columbia. I can give you some very specific examples of that, if you would like.

The fact of the matter is that the human demand for aquatic protein far exceeds the ocean's ability to produce to meet the demands. Aquaculture provides a new way of supplementing the ocean's resources. There are environmental costs associated with, in this case, producing salmon. But if you will read or at least scan through this paper, you will see that those environmental costs in terms of occupation of the landscape and impacts upon the landscape are minuscule in comparison to the environmental costs associated with the loaf of bread that you buy in Overwaitea or the beef patty that you buy in Safeway or many of the other foodstuffs that you eat. They are much, much smaller than those costs.

If we are truly interested in sustainability, then our goal should not be to micromanage one industry to the point that we allow no environmental effect and ignore these other environmental effects. You need to put the effects into perspective.

There are numerous pictures in here and discussions of the environmental effects associated with wild harvests of fish. Our department of fish and wildlife estimates that fully 10 percent of the allowable catch of crabs and prawns in Washington State are caught each year by lost shrimp and crab pots. Twice I have gotten my $10,000 underwater camera entangled in masses of shrimp, prawn and crab traps that have collected on drift logs at several hundred feet of depth and ended up holding my breath while I ripped the whole thing loose and brought up half a dozen or so pots in each case that all contained fish and prawns.

My point is that in my opinion, there are no sustainable ways of producing food on this earth at this time. Everything you buy in the store is produced in an unsustainable way for one reason or another. Our task is not to eliminate all the environmental costs associated with one activity. Our task should be to work towards sustainability of our food resources.

[1520]

You want to do away with aquaculture? Then you either tell people, "You don't eat any more fish," or you do away with aquaculture and you keep catching fish until you've caught the last one.

R. Routledge: I haven't heard anybody on this side of the table say that we want to do away with aquaculture.

R. Austin (Chair): Marty, do you have a comment?

M. Krkošek: Yeah, I'd just like to make one comment. To argue that salmon aquaculture is a sustainable way to feed the world because we have depleting wild fish stocks completely misses the point that the food that's going in to feed the fish in the farm is coming from wild fish which is perfectly suitable for human consumption. By farming salmon, there's actually a net loss of the wild fish supply.

A. Morton: I'll just be very quick. I don't know why Dr. Brooks thinks salmon farming is the only industry in the Broughton that's being mitigated or controlled. My community was just about wiped out when the coho fishery was closed. Everybody in there is tourism-based. This was a huge impact. There are strict regulations on absolutely everybody, so salmon farms are not being singled out.

C. Trevena: Mine's going back a little bit. It's something that Dario mentioned, followed up by Ken, on ways to mitigate the problems. You mentioned fallowing, siting and best management, but you also said that we need to have a baseline.

Dr. Brooks mentioned that we don't know some of the historic past. Where would we start a baseline when we have the industry that is here and working?

There are clearly concerns about it, or else we wouldn't all be sitting around this table right now. Would it be a baseline starting from now? Or would we be trying to track back to where we were a few years ago? I just wanted to get some sense of that.

D. Stucchi: For the Queen Charlotte Strait area, the Broughton and Knight Inlet we're fortunate that we do have some baseline information on some of the physical characteristics, the properties of this area, that go back almost half a century.

When he was training oceanography students, Dr. George Pickard at the University of British Columbia took them out in the summertime to learn the techniques of oceanography. He visited many of the coastal waterways of this province and provided training for the students but left us with a legacy of information dating back some 50 years, half a century, in some cases.

Knight Inlet seemed to be a particularly interesting spot for a number of people — researchers — studying physical processes of mixing between fresh and salt water. Knight Inlet is well studied — probably one of the best-studied, if not the best-studied, fjords in the world.

We are fortunate to have some baseline information. We can't recreate it, usually, but we can start monitoring now, because if the change is occurring slowly, it may suddenly tip if they overload the system. We need to be monitoring, starting as soon as you're able to. It is something that one should try to do, but you have to be very judicious because it would be very costly as well. So we have some baseline information.

In some of the areas on the north coast and the central coast the situation is entirely the opposite. We have very few baseline data to go back on. The only way to go back is to try to incorporate the traditional ecological knowledge. The first nations people certainly have some of that. That's more difficult to incorporate because it's in a different form. It's not usually in a scientific form. There are ways of getting at that baseline.

Some areas will be better than others in terms of what our coverage is, but for looking at large-scale effects, monitoring, as Ken mentioned, I think is an important component of that. But one has to be very judicious as to how one does that.

Then, you don't always know what's going to happen. There are effects that we never anticipated. I think Rick Routledge put some of those up on one of his view graphs.

You can't know everything. You try to do the best you can with what you think will happen. You will be surprised, and we have been surprised. We probably will continue to be surprised. You try to manage those risks as best you can, where you can.

[1525]

S. Simpson: Over these 29 or 25 or however many public sessions that we had, one of the interesting things that we heard continually from organizations…. Those organizations that are concerned about aquaculture have consistently said: "The industry is going to remain." The question is: in what context?

On the other side — those people in the industry — we consistently heard from them…. When the question was put about what the priority needs to be in our finding, they all agreed that the priority has to be the integrity of the wild salmon, and we have to ensure the protection of the wild salmon. There really is some consensus here, I think, though it's certainly lost in a lot of other stuff and a lot of disagreement.

The question I have relates to things that I've been hearing here and elsewhere, which is…. There certainly is a body of thought that says that there are very serious impacts on the wild salmon by fish farms. There's also a body of thought…. We heard it here from Dr. Jones and Dr. Beamish, and we've heard it from Dr. Brooks and from Dario, that there's inconclusivity in the information here.

We simply don't know a lot of the things that are assumed. The assumptions are ones that aren't accepted here, and that's inconclusive. We don't have the information we need to draw those conclusions that some of our friends on this side of the table have drawn.

The question I have is this: if that's the case, do we then need to be drawing on additional information that we don't today? We've heard that the industry, among others, collects a series of data around fish health, around other information. They claim some of it is proprietary, and I understand that. But that's information that could be important in making some of these determinations about what we do and don't know.

I guess the question I'd put out is: do we need to find ways to access that information that doesn't compromise their proprietary rights as business people but that gets that information in the hands of scientists who can help to draw more definitive conclusions than, certainly, some of the people at the table say we have today?

I'd put the question to both sides.

D. Stucchi: Can I take a stab at that? I agree. I think that some of the information that's deemed proprietary would be more useful out on the table for everyone to see. I was talking with Claire about that just today at lunchtime.

There's a lot of information out there, and sometimes it's not the problem that it's being purposely hidden or kept away from people. It's just difficult. There's so much of it, and it's so difficult to get at.

The province of B.C. has a finfish aquaculture waste control regulation, and in that regulation it stipulates that the industry, the proponent, is to go out and monitor it at specified locations, at their farmsite and far from their farmsite, at a particular time in their production cycle. After the farm production cycle is finished, they have to monitor several stations before they can restock the site. They specify what kind of monitoring needs to be done.

That information isn't widely available. There's a lot of it, but it resides in the databases of the Ministry of Environment, I believe, in Nanaimo. It's just that people don't know how to get at it.

S. Simpson: And you can't access that?

D. Stucchi: We can access it. Even if it's for ourselves — and we have accessed it — it's been difficult to get access to it. I don't think we're denied access. It's just difficult to know about it, first off.

It's in an inaccessible form. Well, it's accessible, but it's not compiled and formatted in the way that you can easily get at it. You would be inundated with a truckload of data, and you don't know what to do with all the data.

S. Simpson: To get that much, that you really needed….

D. Stucchi: To synthesize it down to information becomes problematic, so there's a data management issue. They do file it electronically, but it takes a lot of work to get. The information is there. You just need to know how to mine it to get it out. And many people don't know it even exists or don't know how to ask the right questions to get at it.

It would be very useful to have that data available so that people know about that data, but more importantly, to have it processed or put in a form that you can then easily do some interpretation, provide an information content with it.

[1530]

K. Brooks: I just want to reinforce what Dario said. When I undertook this task for MOE, I was sent Word files. From those Word files, I have created a Statistica database that has a million and a half cells in it. I don't know if you can imagine how tedious and hard filling a database of that size is. But that database is now available in Statistica.

The point I want to make is that if you want additional monitoring, if you want additional transparency of data from Ministry of Environment or from the sea lice action plan — I'm speaking as a private citizen — it takes resources on the part of these agencies. You've got a couple of guys, Eric McGreer and Bernie Taekema, working in Ministry of Environment, neither one of whom is a statistician. They are overwhelmed with work.

If you want more information, that information costs money, and those agencies need more funding. There needs to be more resources made available to do the kinds of things that you're talking about doing, because none of this is free.

S. Simpson: So just to follow that up. We've heard, as I think you've said, a lot of conflicting points of view over the last number of months, and we'll hear more, I'm sure, as we go along. At a government level, as we look at the things that can be done, if the government is going to provide better audit or oversight or monitoring or data, the government is going to need to invest additional resources over and above what we've put today on this file?

K. Brooks: I would say absolutely. I can't speak for the federal government, but….

S. Simpson: No, just at the provincial level. I don't speak for the federal government.

K. Brooks: I certainly think that's true.

R. Routledge: Some kinds of data are awfully easy to provide. They don't take a lot of time — really basic, fundamental data like how many fish are on the farms, what were the numbers of lice recorded in the last audit. That doesn't take a lot of effort, and it would be tremendously valuable to people like us here in trying to do our work.

We often get criticized for not having data on farms, and people are trying to block our publications because we don't have it. We need it, and it's simple.

S. Simpson: One last question around that, and this may not be a question that you can answer, because you're a scientist. You're not business folks in that sense. Based on what you know about doing research in this area, are there any particular proprietary reasons that would hurt a business's competitive opportunity or advantage by supplying that information or having it be public? I don't know, so I'm just wondering.

A. Morton: Absolutely. If Burdwood would tell me what strain of IHN they had and I were to make that public, and Marine Harvest found it on their farms or the people with the chinook salmon in the Bonneville Dam in Washington State found it in their chinook salmon, somebody would be liable. These guys are dealing with information dangerous to themselves. That's why they don't want to share it.

K. Brooks: Some of this information is available. I needed sea lice count data on salmon at some of the Marine Harvest sites a couple of months ago. I simply went to their website. I don't have a special password or anything, and I downloaded the data. It's all right there.

There obviously is some proprietary data. Some companies guard their FCRs because they use what they feel are unique feeding mechanisms and programs, and they don't want to give away a competitive edge. There are a number of reasons why some of that data might be considered proprietary.

One of the things that we're not going to solve here, but as a kind of a pie-in-the-sky person dedicated to sustainability…. One of the reasons information is guarded by companies is because there is a perception that whatever they give out will be used against them by some party. So there is a reluctance to give out any information.

I can guarantee you that if there was a more cooperative, give-and-take, rigorous, scientific discussion of these things, the information would free far more readily. But in the current environment, in the environment that's existed in this province over the last — I don't know what — ten years, there's a real reluctance to give out anything, because somebody's going to beat you over the head with it.

[1535]

R. Routledge: Very quickly. Craig Orr and Marine Harvest and others have been working very effectively at making these data available, generating good, solid agreements. It has been a tremendous first step, and I think that's where Ken is getting his data from — from the Internet. That's a great step forward.

D. Stucchi: Yeah, I would like just to reinforce that. I think we have an example of where we're moving away from this very polarized nature to companies and NGOs working together. One of the outcomes, as you've seen, is Marine Harvest posting their sea lice monitoring data. I wish the other companies would do likewise, because I think in this particular case that information is required under a provincial regulation, if I understand correctly. I haven't seen the industry clearly articulate why it needs to be proprietary. You have probably the largest company on this coast putting it up on their website. I think that would be beneficial and a good step forward.

R. Cantelon (Deputy Chair): I just really thank you all for being here today. It has been very informative. It's been a long day and a tough day. I wasn't encouraged, Dr. Brooks, to hear that there are a million cells of information. I think that exceeds my current capacity.

I'd like to invite you all to be our scientific filter and join us on our future trips and whatnot, to go around, and you can….

G. Coons: To Klemtu.

R. Cantelon (Deputy Chair): Klemtu and other notable locations.

I guess my question is following on Shane Simpson's comment or question. We're hearing a bit of it come up today. Maybe we're all wearing down, and maybe that's how we have to bring agreement. I guess if anything that this panel can do…. Am I hearing from you all that if we could create an environment, a forum, whatever, to disseminate information that's not available to Alexandra Morton or to make all of that more public and easier to access and create, perhaps, a place where we can all talk about this, as we've pretty much been able to do today, in an open way…? Do you think that would be useful for our panel? I'd like to hear any comments you'd like to have to say about that.

D. Stucchi: I agree. I can't see how you could not agree to that.

K. Brooks: I don't know if you folks can help with this. I have encouraged Jon O'Riordon and John Fraser to approach their task in a multidisciplinary, international forum.

We talk in science a lot about multidisciplinary efforts, where we'd bring biologists and parasitologists and hydrodynamicists and benthic ecologists — an array of scientific expertise — to bear on a problem. But we almost never do it.

There are very few examples of having accomplished that. If there's anything that this group can do to foster that kind of multidisciplinary approach to solving these problems, I think everyone would be really surprised at how much more efficient the process would be and how much more quickly we would achieve the insights that we want.

R. Austin (Chair): Noting the time and recognizing that there are still plenty of issues we could canvass, I'm going to suggest that we don't go to question 5. We've actually spoken to quite a bit of it. I'm going to ask instead that the five remaining panellists give their five-minute sum-up, and then we'll call it a day.

I'd like to start with Ken, if you'd like to sort of do a five-minute overview of your thoughts about sustainable aquaculture.

K. Brooks: My sense of aquaculture is that it is a new way of producing food — new in some senses; very, very ancient in other senses — and that it is creating significant social change in the communities where it is coming. I believe that it is essential to managing and sustaining wild sources of fish, because it supplements those stocks, and it will help keep us from catching the last fish in the ocean.

There are environmental costs associated with aquaculture. There are problems that we know about and other problems that have been suggested but which we don't about. We need to continue to investigate those.

[1540]

But rather than investigating from the point of view of "how do we get rid of salmon farms in the Broughton?" or "keep them out of Klemtu" or "keep them out of one of the other sounds," I think we would make far greater progress towards sustainability if we approached these problems from the point of view of identifying them, verifying them and then solving, figuring out.

I have a great deal of faith in human ingenuity and in our ability to solve problems. When I was doing mediation for the Governor, his natural resources cabinet would always ask me: "What are your chances of successfully mediating this issue?" I would always give them a low probability of success until I got the opposing sides to agree to address specific issues. Finding solutions to those specific issues was always far, far easier than getting people to agree to even identify them and to work at solving them.

I'm not going to say that aquaculture has no environmental effects. I'm probably the world's expert in the benthic effects associated with near-field effects associated with aquaculture. I can quantify those. I can discuss them ad nauseam. They're real. They need to be managed. I think the Ministry of Environment is doing as good a job as anybody in the world in terms of managing those effects.

If we could achieve a less polemic exchange, as we have just discussed, that would greatly facilitate finding solutions to problems, instead of arguing about whether or not aquaculture should remain a part of the British Columbia economy.

D. Stucchi: I'll just touch upon three points. We've discussed them today, and they were brought up, I

think, in the closing slide that Dr. Riddell showed during our presentations last week.

The first — and this has been mentioned, as I just said — is collaboration and cooperation between the researchers, the different government agencies, the industry, the local communities, first nations. I think it's essential if we're to continue to work on the issues that have been identified and on future issues that will come up. That includes respect for data, as a way Brian had put it, but also openness to sharing data and to making it more transparent. I think that has to be part of it. There are some signs of progress in that regard, but I think we still have a long way to go. The signs are encouraging.

Second, there's the development of and commitment to strategic research plans. Another agency of the provincial government, the B.C. Pacific Salmon Forum, is moving in that regard and developing research proposals to address three main issues with regard to salmon aquaculture. It's bringing together a diverse group of people, including the usual suspects at DFO and the provincial ministries as well as the first nations, and there's a component of community involvement in that.

The third one is this idea of open and effective communication and involvement of the local community in decision-making. The DFO can't do it alone, nor should they. We recognize that the picture is larger than just one single federal or provincial agency. It really needs a broader perspective, and those other perspectives need to be included in a meaningful way in the planning process and the implementation of some of the work and in the decision-making.

I don't know how we're going to get there from here, but it has to change, and I think there's recognition that that needs to change as well. How we go down that road, which I'm sure will be fraught with difficulty and conflict…. But I think it's the right path to take. That's the challenge we have ahead of us, and it's been recognized.

M. Krkošek: This coast really depends on wild salmon, whether you look at ecosystems or communities or economies. It has a long history with wild salmon. I think we've seen enough information today.

[1545]

There's enough information in the literature to suggest that there are potentially severe problems associated with aquaculture that can threaten wild salmon stocks. It's not clear how severe these problems may be, and it's not clear whether or not there are solutions and what those solutions could be. But we're making progress that way.

I think there's enough information there to ring alarm bells and say that maybe we should hold our horses a little bit and proceed with a little more caution and maybe convince ourselves that aquaculture and wild fish can successfully be managed and coexist before we go ahead and allow the expansion of this industry throughout the entire coast. Let's convince ourselves that we can first have wild salmon and farm salmon before we go that route, because maybe that's not possible. Right now it's not clear.

R. Routledge: Two pieces of information I want to put to you at the end here. The first is that Brian Riddell mentioned on Thursday that he heard of some study being conducted further south of the Broughton. That's the one that the three of us have worked on. We indeed again found evidence of elevated lice levels near farms in that area.

I do not personally believe that there's anything unique about the Broughton. There's nothing unique about the B.C. coast. This is found all over the world where there are wild salmon and fish farms.

Nor is it restricted just to pink and chum salmon. We found elevated lice levels on sockeye salmon and even on larval herring in that area. These larval herring are tiny little fish. They're not the salmon louse we found on them — the other, smaller louse. These fish are so small that if we were to do some kind of study on the impact on those, I'm almost positive we'd find that it would be very significant.

I've said some things about sockeye salmon on the central coast a couple times. I just wanted to reinforce that. Rivers Inlet sockeye used to have a million fish coming back. In 1999 they were down to an estimated 3,600. They've since rebuilt to 110,000. A similar story at Smith Inlet to the south.

What really concerns me from a scientific point of view are the numerous small sockeye populations around the Bella Bella area. Quite a few of them used to have about a thousand fish. The last information I found from a Pacific Fisheries Resource Conservation Council document was that they might be around ten to 20. Ten to 20 fish is not enough to protect the genetic integrity of that stock. To put a fish farm there is asking for trouble such as we have with the Atlantic salmon in the Bay of Fundy. That would be irreversible loss.

These fish are small. They're two grams coming out of Rivers Inlet typically, and somewhat larger when the stock was really depressed. But I've been in there for four years, and they're often really small — small enough that you would expect, given evidence everywhere else around the world, that you're going to have problems with marine survival of those fish even more than we have now.

There's a real possibility of irreversible damage. I can't prove to you that will definitely happen, but the whole point of the precautionary approach is that one doesn't have to do that. One has to provide a reasonable amount of evidence, and I am confident that it is there.

I'll finish by reading a quote from Malcolm Windsor, the secretary of the North Atlantic Salmon Conservation Organization. That's not an NGO. That is an intergovernmental panel. We belong to that. We support this organization. Malcolm says: "The science confirms that cultured salmon can have significant negative impacts on the wild stocks. Real progress has been made in managing their actions, but some significant challenges remain, particularly with regard to further reducing impacts of escapees and sea lice."

As Alex alluded to in the executive summary to this report, he and this other fellow write: "The conveners propose that interactions between farmed and wild salmon need to be virtually eliminated, not just reduced."

A. Morton: Throughout this day I keep hearing from the Department of Fisheries and Oceans that the problem is too confusing; we need to take an ecosystem approach; we need baseline data that's no longer available in the Broughton; we need more money.

[1550]

I wanted to just finish my presentation to you, because this last bit takes some of DFO's quotes to you. Last Friday they presented a summary. Their first item was: "In areas of B.C. outside the Broughton Archipelago, the prevalence of *L. salmonis* is generally less than 5 percent in areas with and without farms." This is incorrect. In areas outside the Broughton, wherever I have looked that there are farms, there are serious sea lice problems — Jackson Pass, Port Hardy, Quadra Island and recently around the fish farm packing plants. I've been looking there.

They go on to say: "However, the consistency of the reported pattern is not evident in a more extensive DFO sampling program." They're saying here they don't believe or they don't accept Marty Krkošek's work because DFO isn't finding that.

I'm partnered with DFO, so I know what we're doing. These red spots are where we set the beach seine, and then these entire areas are analyzed. Where you see a yellow bar, DFO makes one number. Now, some of these sites will include estuaries by salmon farms, in between salmon farms, and you get one number reporting for those entire yellow streaks.

Here's what Marty did. Every one of these yellow dots is Marty's number. He is reporting, on a very fine scale, what is going on exactly as the fish approach the farms or are at the farms or past the farms. Krkošek has fine resolution; DFO has not. DFO blurs fish farms at farms, at rivers and in between into one number, which in this case is meaningless. It does not tell you what's happening to those fish as they pass the farms.

In addition, for some reason DFO is only presenting to you on the motile-stage lice, lice we know are going to appear on the fish long after they've passed the fish farm. Marty's data also does not show motiles associated with fish farms. But what Marty has done is look at the copepodites, the chalimus, the pre-adults and the adults, and that's how he gets his pattern. Once again, he's doing a very fine-scale analysis.

"Research on the impact of sea lice on individual salmon differs between studies conducted in the Broughton and those at the Pacific Biological Station." This difference is insignificant. The difference between what Simon Jones and I have found is insignificant because Simon used much bigger fish. They know it; I know it. To pretend this is unresolved is silly.

Then finally: "While DFO has increased monitoring of pink and chum salmon returns in the Broughton, results do not confirm or support a direct association between sea lice on juveniles and subsequent adult returns." They absolutely do support an association between infection and adult returns. You've got these low numbers. DFO is scanning the rivers intensively for the very last pink salmon, and you have this enormous surge in the one year that they fallow the farms.

That's a huge signal to anyone looking. It's a road sign. This is as much an indication of a problem as we're going to get.

Brian Riddell, in the Campbell River *Mirror*: "At this time our research does not support the close association between salmon farms, sea lice and loss of wild salmon." Well, we now know their research does not support close association because they didn't look closely. It was a broad-brush approach to a fine-resolution issue.

We have species going extinct every single day on this planet, and we still don't recognize the trend. The only reason you and I and the rest of us are here today, I believe, is denial strategy. Denial strategy has three easy steps, and scientists are using it all over the world to prevent progress — government scientists and industry scientists.

First they say there's no problem, then they say it's too confusing to figure out, and then they tell you it's good for you. They're telling me fish farming is good for my community. Not a single person in my community is hired by the fish farms.

If the Broughton salmon go extinct, we're responsible. Thank you very much for your time.

R. Austin (Chair): Thank you very much. On behalf of the committee, I'd like to thank all of you for coming here today and taking a day out of your busy lives to come and share your knowledge with us. I appreciate it. With that, I would like a motion to adjourn.

The committee adjourned at 3:55 p.m.

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