Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River

Commission d'enquête sur le déclin des populations de saumon rouge du fleuve Fraser

Public Hearings

Audience publique

Commissioner

L'Honorable juge /
The Honourable Justice
Bruce Cohen

Commissaire

Held at:

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Federal Courthouse
701 West Georgia Street
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Salle 801
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701, rue West Georgia
Vancouver (C.-B.)

le lundi 22 août 2011

APPEARANCES / COMPARUTIONS

Brock Martland Jennifer Chan Kathy L. Grant	Associate Commission Counsel Junior Commission Counsel Junior Commission Counsel
Mitchell Taylor, Q.C. Jonah Spiegelman	Government of Canada ("CAN")
Clifton Prowse, Q.C. Tara Callan	Province of British Columbia ("BCPROV")
No appearance	Pacific Salmon Commission ("PSC")
No appearance	B.C. Public Service Alliance of Canada Union of Environment Workers B.C. ("BCPSAC")
No appearance	Rio Tinto Alcan Inc. ("RTAI")
Alan Blair Shane Hopkins-Utter	B.C. Salmon Farmers Association ("BCSFA")
No appearance	Seafood Producers Association of B.C. ("SPABC")
Gregory McDade, Q.C.	Aquaculture Coalition: Alexandra Morton; Raincoast Research Society; Pacific Coast Wild Salmon Society ("AQUA")
Tim Leadem, Q.C.	Conservation Coalition: Coastal Alliance for Aquaculture Reform Fraser Riverkeeper Society; Georgia Strait Alliance; Raincoast Conservation Foundation; Watershed Watch Salmon Society; Mr. Otto Langer; David Suzuki Foundation ("CONSERV")
Katrina Pacey	Area D Salmon Gillnet Association; Area B Harvest Committee (Seine) ("GILLFSC")

APPEARANCES / COMPARUTIONS, cont'd.

No appearance	Southern Area E Gillnetters Assn. B.C. Fisheries Survival Coalition ("SGAHC")
No appearance	West Coast Trollers Area G Association; United Fishermen and Allied Workers' Union ("TWCTUFA")
No appearance	B.C. Wildlife Federation; B.C. Federation of Drift Fishers ("WFFDF")
No appearance	Maa-nulth Treaty Society; Tsawwassen First Nation; Musqueam First Nation ("MTM")
No appearance	Western Central Coast Salish First Nations: Cowichan Tribes and Chemainus First Nation Hwlitsum First Nation and Penelakut Tribe Te'mexw Treaty Association ("WCCSFN")
Brenda Gaertner Crystal Reeves	First Nations Coalition: First Nations Fisheries Council; Aboriginal Caucus of the Fraser River; Aboriginal Fisheries Secretariat; Fraser Valley Aboriginal Fisheries Society; Northern Shuswap Tribal Council; Chehalis Indian Band; Secwepemc Fisheries Commission of the Shuswap Nation Tribal Council; Upper Fraser Fisheries Conservation Alliance; Other Douglas Treaty First Nations who applied together (the Snuneymuxw, Tsartlip and Tsawout); Adams Lake Indian Band; Carrier Sekani Tribal Council; Council of Haida Nation ("FNC")
Joseph Gereluk	Métis Nation British Columbia ("MNBC")

APPEARANCES / COMPARUTIONS, cont'd.

Tim Dickson Nicole Schabus	Sto:lo Tribal Council Cheam Indian Band ("STCCIB")
No appearance	Laich-kwil-tach Treaty Society Chief Harold Sewid, Aboriginal Aquaculture Association ("LJHAH")
No appearance	Musgamagw Tsawataineuk Tribal Council ("MTTC")
Lee Schmidt	Heiltsuk Tribal Council ("HTC")

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Vancouver, B.C. /Vancouver (C.-B.)
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THE REGISTRAR: The hearing is now resumed.
MR. MARTLAND: Mr. Commissioner, I am appearing, Brock Martland, M-a-r-t-l-a-n-d, with me is Jennifer Chan and Kathy Grant. Ms. Chan is my counsel as well for the Commission on the Disease hearings; Ms. Grant for the Aquaculture hearings to follow.

As we begin today, I'd like to take just a brief moment to acknowledge the passing this morning of the Honourable Jack Layton, the Leader of the Opposition, who of course made a most meaningful contribution to Canadian public life.

I also had a note that Mr. Taylor wished to address you on one brief point as we start the day.

MR. TAYLOR: Mr. Commissioner, Mitchell Taylor for the participant Canada, and with me is Jonah Spiegelman. Also behind me at the far back is Jeff Miller. He's a law student, and I am seeking leave if he might be at the front, Mr. Commissioner.
THE COMMISSIONER: Yes, of course, Mr. Taylor, that's fine.
MR. TAYLOR: Thank you.
MR. MARTLAND: Mr. Commissioner, by way of a few brief remarks as we start today. We begin, of course, the hearings on the topic of disease, which run for three-and-a-half days, then they're followed by hearings on the topic of aquaculture. We've made a schedule change, we communicated that Friday, with respect to the second disease panel, Dr. Kristi Miller and Dr. Kyle Garver, adding a half day from that panel, but taking that half day, if you will, from the Project 5 panel, which is the Commission's Reports on Aquaculture. So in the short we will have Drs. Miller and Garver running Wednesday, and then until noon on Thursday, at which point we'll start with the Panel 5 evidence.

I also want to say at the outset, as Commission counsel we're grateful to all participants' counsel for their assistance. We have a schedule in the next three weeks or so that

is ambitious. It reflects our preference, but also the preference of participants to have a number of important witnesses as opposed to only a select few. Of course, the trade-off in that equation is that counsel must be focused and disciplined in their questioning, and I'm grateful to them in taking that approach and agreeing to respect the time allocations.

I can say at the outset I will be perhaps making myself a bit of a pest to my colleagues in reminding them of the time. I'll be asking them through these hearings to cede the floor when their time is finished, and to understand that if they don't, they'll be using the next lawyer's time, and that if there are outstanding questions, if somehow they have not asked an important or a vital question at the start of their questions, that they look to address the Commission at the end of the hearing and to see if there's time at that point, rather than carrying on and pushing our schedule.

On that, Mr. Commissioner, we're in a position to begin the first panel of experts, Drs. Michael Kent and Dr. Craig Stephen, both of whom have prepared technical reports, Dr. Stewart Johnson and Dr. Christine MacWilliams from DFO. If they might be affirmed, please, Mr. Registrar.

THE COMMISSIONER: Put on their microphones, please.

STEWART JOHNSON, affirmed.

MICHAEL KENT, affirmed.

CHRISTINE MacWILLIAMS, affirmed.

CRAIG STEPHEN, affirmed.

THE REGISTRAR: I'm sorry, I need your names.
DR. KENT: Michael Kent.
THE REGISTRAR: Yes.
DR. JOHNSON: Stewart Johnson.
DR. STEPHEN: Craig Stephen.
DR. MacWILLIAMS: Christine MacWilliams.
THE REGISTRAR: Thank you. Counsel.
MR. MARTLAND: Thank you.

EXAMINATION IN CHIEF ON QUALIFICATIONS BY MR. MARTLAND:

Q I'll begin, if I might, with number 4, and I'll be referring as we move through this to lists -- to, sorry, documents on our list of proposed exhibits. And Dr. Kent, I'll begin questions of you. First of all, I hope you'll recognize on screen your *c.v.*, sir?

DR. KENT: Yes.

Q And just -- there we go, you see the red light on the microphone.

DR. KENT: Yes, I do.

MR. MARTLAND: Thank you. And if I could ask this be marked as the next exhibit, please.

THE REGISTRAR: Exhibit number 1448.

EXHIBIT 1448: *Curriculum vitae* of Michael Kent

MR. MARTLAND:

Q I will briefly, to confirm your background, sir, you are a professor in the department -- Departments of Microbiology and Biomedical Sciences at Oregon State University and also you are the author of Technical Report 1, which we'll be addressing in a moment, a report for this Commission.

DR. KENT: Yes, that's correct.

Q I understand that you hold a Ph.D. in Comparative Pathology from the University of California Davis from 1985, an M.Sc. in Biology from San Diego State University from 1981, a B.Sc. in Fisheries from Humboldt State University from 1977 and that your research interests include fish diseases and parasitology.

DR. KENT: Yes, that's correct.

Q Your laboratory conducts studies of diseases related to both wild and cultured fish populations, including the pathological and physiological effects of population on salmonid fishes in mountain lakes; is that true?

DR. KENT: That's correct.

Q And is it correct that you've served as a co-advisor to a number of graduate students, indeed some of those students will be appearing here as witnesses, one of whom is Craig Stephen, as well as Dr. Sonia Saksida?

DR. KENT: That's correct.
Q And on the basis of this -- I should also ask this. You have a background, having worked for the DFO; is that correct?
DR. KENT: Yeah, that's correct. I worked with them from 1988 through 1999 and cumulated my -- my career with them as Head of the Fish Health Section, which I became Head of the Fish Health Section in 1997.
MR. MARTLAND: Thank you. On the basis, Mr. Commissioner, of the *c.v.* and this witness's qualifications, I'll ask to have him qualified as an expert specifically with respect to fish disease and parasitology, please.
THE COMMISSIONER: Thank you.
MR. MARTLAND:
Q Now I'd like to have document number 5, please, brought up, Mr. Lunn. You'll see in a moment, Dr. Kent, your report, which I referred to a moment ago.
DR. KENT: Yes, that's my report.
MR. MARTLAND: I'll ask this be marked as the next exhibit, please.
THE REGISTRAR: Exhibit 1449.

EXHIBIT 1449: Cohen Commission Technical Report 1 - Infectious Diseases and Potential Impacts on Survival of Fraser River Sockeye Salmon, February 2011

MR. MARTLAND:
Q And I believe there's a corrections or errata sheet that associates with that document. I may touch on it very briefly, but if I might ask, Mr. Lunn, if you could put that on the screen. And that's just two things about page 20, but first of all the second word there was misspelled, it should have been "*salmonsitica*", and secondly that the ranking that's described in the table on page 20 doesn't correlate to what the text of your report says. It should have been "moderate"; is that correct?
DR. KENT: That's correct.
MR. MARTLAND: And I'll ask this sheet please be marked as the next exhibit.
THE REGISTRAR: Exhibit 1450.

EXHIBIT 1450: Errata sheet for Cohen Commission Technical Report 1, undated

MR. MARTLAND:
Q Dr. Johnson, I'll ask Mr. Lunn next to please bring up number 1 on our list of documents. And I'll ask, I hope my easiest question, which is do you recognize your *c.v.*?
DR. JOHNSON: That's my *c.v.*
MR. MARTLAND: If this might be the next exhibit, please.
THE REGISTRAR: Exhibit 1451.

EXHIBIT 1451: *Curriculum vitae* of Stewart Johnson

MR. MARTLAND:
Q With respect to your background, you head the Aquatic Animal Health Section of the Salmon and Freshwater Ecosystems Division in the DFO's Pacific Region Science Branch, and in that capacity, sir, I understand that you oversee the work of various DFO staff investigating or monitoring aquatic pathogens and diseases, a list that includes again a number of folks who are testifying, Dr. Christine MacWilliams, who is on the panel today, as well as Dr. Kyle Garver and Dr. Simon Jones; is that correct?
DR. JOHNSON: Yes, I do.
Q You hold a PH.D. in Biological Sciences from Simon Fraser University from 1991, an M.Sc. in Biological Sciences from Dalhousie in 1986, and a B.Sc. in Biological Sciences from the University of Victoria from 1978; is that right?
DR. JOHNSON: Yes, that's correct.
Q In addition, you've completed post-doctoral training, both at the University of B.C. and Stanford University, and I understand that among other positions, you served as an external reviewer on DFO Pacific Science Advice Review Committee, as a science advisor on the Genome BC project called "Genomics in Lice and Salmon", as well as having been a past chair of the PICES Working Group on Environmental Interactions of Marine Aquaculture; is that right?
DR. JOHNSON: Yes, that's correct.
Q Your major research interests include diseases,

immunology, physiology, and the husbandry of aquatic animals, including research on host pathogen interactions involving what I'll be calling through the hearings, Mr. Commissioner, I expect, *Leps*, but the proper name is *Lepeophtheirus*, I take it, *salmonis*?

DR. JOHNSON: Yes, that's correct.

Q And *Aeromonas salmonicida*.

DR. JOHNSON: *Aeromonas*.

Q *Aeromonas*.

DR. JOHNSON: *Salmonicida*.

Q All right. And apart from the pronunciation, I hope those facts are accurate, sir?

DR. JOHNSON: Yes, they are.

MR. MARTLAND: I'll ask to qualify Dr. Johnson as an expert in aquatic animal diseases, immunology and physiology.

MR. TAYLOR: I agree with that so far. I have a further question, if I may.

CROSS-EXAMINATION ON QUALIFICATIONS BY MR. TAYLOR:

Q Dr. Johnson, are you knowledgeable in parasitology?

DR. JOHNSON: I am knowledgeable in parasitology, especially as it pertains to studies of sea lice.

Q And is that of long standing, that is, you've been knowledgeable in that area for many years?

DR. JOHNSON: My Ph.D. thesis was the first major studies on *Lepeophtheirus salmonis* that were conducted.

MR. TAYLOR: And therefore in addition to what Mr. Martland has proposed, I think that Dr. Johnson is an expert in parasitology, as well, as it pertains to fish.

MR. MARTLAND: Unless counsel has an objection to that, I don't have a difficulty with that formulation being added.

THE COMMISSIONER: Very well, thank you.

EXAMINATION IN CHIEF ON QUALIFICATIONS BY MR. MARTLAND, continuing:

Q And I'd like to have number 7, please, brought up on screen, simply just to complete our understanding, and I don't expect to be asking you questions about this. But I hope once it's

righted, you'll see that this an organizational chart with respect to on page 1, the Salmon and Freshwater Ecosystems Division, on page 2 you'll see the Molecular Genetics -- I'm sorry, Mr. Lunn, I've made this challenging. But again, once in a moment I think you'll see the Molecular Genetics and the Animal Aquatic -- sorry, Molecular Genetics organizational chart, and then on the third page in a moment, I expect you'll see the Aquatic Animal Health Section is that right?

DR. JOHNSON: Yes, that's correct.

Q And this accurately describes the Department's structure with respect to these divisions or branches?

DR. JOHNSON: Yes, it's the most up-to-date version.

MR. MARTLAND: I'll ask this be marked as the next exhibit, please.

THE REGISTRAR: Exhibit 1452.

EXHIBIT 1452: Organizational Charts of DFO Salmon and Freshwater Ecosystems Division, May 2011

MR. MARTLAND:

Q Dr. Stephen, I'll move to you next and have a look at number 2 on the list of exhibits, sir, which I hope will be your *c.v.*; is that correct?

DR. STEPHEN: And it's a "Highlights" of my *c.v.*, yes.

MR. MARTLAND: And if I might ask that this be marked as the next exhibit.

THE REGISTRAR: Exhibit 1453.

EXHIBIT 1453: *Curriculum vitae* Highlights Specific to the Cohen Commission Mandate of Craig Stephen

MR. MARTLAND:

Q You serve as a Professor in the Faculty of Veterinary Medicine and the Faculty of Medicine at the University of Calgary, and you're the Founding Director and President of the Centre of Coastal Health, which is an independent non-profit organization that conducts research primarily in the areas of public health and fish and wildlife health; is that right?

DR. STEPHEN: That's correct.

Q And you're the primary author of Technical Report

1A, which we'll look at in just a moment.
DR. STEPHEN: Yes, correct.
Q You hold a Ph.D. in Epidemiology and a Doctor of Veterinary Medicine from 1987. The first Ph.D. from 1995, the doctorate from 1987, both from University of Saskatchewan?
DR. STEPHEN: Correct.
Q Your doctoral work focused on emerging diseases in fish populations, and your research interests include aquatic animal health assessments, and surveillance in the ecology of emerging diseases?
DR. STEPHEN: Correct.
MR. MARTLAND: If I might ask on the basis of this witness's, at least highlights from his *c.v.* as well as his background, that he be qualified as an expert in veterinary epidemiology with a specialty in the ecology of emerging diseases and surveillance of aquatic animal health and disease.
THE COMMISSIONER: Yes, very well. Thank you.
MR. MARTLAND:
Q And if I might have number 6 brought up, please, on the screen in front of you, it's got the same cover, I suppose, but, Dr. Stephen, you'll recognize that as being your report?
DR. STEPHEN: Yes, I do.
Q And it focuses, and we'll obviously be speaking about this, but it focuses on the question of salmon enhancement facilities and disease vis-à-vis Fraser sockeye?
DR. STEPHEN: Correct.
MR. MARTLAND: I'll ask this be marked as the next exhibit, please.
THE REGISTRAR: Exhibit 1453.
THE COMMISSIONER: I think it's 1454.
THE REGISTRAR: I'm sorry, 1454.

EXHIBIT 1454: Cohen Commission Technical Report 1A - Hatchery Diseases, July 2011

MR. MARTLAND: And, Mr. Lunn, I know I have you moving fast and furious on a Monday morning, but I'd like to move to number 3 on our list of documents. Dr. MacWilliams, you'll recognize that as being your *c.v.*?
DR. MacWILLIAMS: It is.
MR. MARTLAND: I'll ask this be marked, please, as an exhibit.

THE REGISTRAR: Exhibit 1455.

EXHIBIT 1455: *Curriculum vitae* of Christine MacWilliams

MR. MARTLAND:
Q And, Dr. MacWilliams, you served both as a Fish Health Veterinarian for DFO Salmonid and Enhancement Program, as well as the Laboratory Animal Veterinarian for DFO Pacific Region Science Branch, and your responsibilities include coordinating fish health disease investigations, providing management recommendations on disease prevention, mitigation and therapeutic intervention, educating salmonid enhancement facility operators on biosecurity, and conducting surveillance for fish pathogens of concern; is that right?
DR. MacWILLIAMS: That is.
Q You hold a Doctor of Veterinary Medicine from The Atlantic Veterinary College from 2000, an M.Sc. in Salmonid Pathology, also from the Atlantic Veterinary College from 2008, and a B.Sc. in Biology from the University of PEI from 1989; is that right?
DR. MacWILLIAMS: That is correct.
Q And your past research have included infectious salmon anaemia virus, ISAV, as well as *Leps*?
DR. MacWILLIAMS: It has.
MR. MARTLAND: I'd like to have Dr. MacWilliams qualified, please, as an expert with respect to veterinary sciences with a specialty in fish health, please.
THE COMMISSIONER: Thank you, Mr. Martland.

EXAMINATION IN CHIEF BY MR. MARTLAND:

Q Now, I'll begin my -- just to, I hope, forecast a sense of my questions, I plan to focus my first questions on Dr. Kent and your report, sir, but in doing that, I'll certainly be turning to the other witnesses for comments on some general and specific points, and then I'll spend some time addressing Dr. Stephen's report.
Dr. Kent, if I might start at the outset - and this is a theme, Dr. Stephen, I'll pick up with you as well - about, with respect to, if you

will, challenges to having the amount of information and data that you wish to have to do this report, you offered a comment to the effect that your report was significantly hampered by the lack of scientific research on disease. And, Dr. Stephen, I think you've made similar kinds of comments with respect to limitations that may have hindered or hampered your work in your technical report.

I'll pause just to be clear that these are both technical reports, itself being, if you will, a technical term, Mr. Commissioner, in that they're commissioned by this inquiry and prepared for the purpose of this inquiry with a view to asking specific questions relating to Fraser sockeye.

I'd like to at a general level engage on this question of the known and the unknown, and having as much as we can some understanding of the significance of the unknowns with respect to pathogens and disease.

Dr. Kent, first, that's a long preface, and I'll spend less time talking from here forward. But first, I understand that you hold the view there's limited research on diseases and wild stocks in contrast to captive stocks whether in an aquaculture facility or hatchery or similar facility.

DR. KENT: Yes, that's correct.

Q Could you comment on that and explain that, why that's the case.

DR. KENT: Sure. Historically, not only within the Pacific Region of DFO, but in general on -- in research on salmonid diseases, most of the emphasis has been directed towards investigations on disease phenomena and within hatcheries or captive populations. And since, you know, or I'd say probably 50 years ago, would fish -- the field of fish disease for 50 or 70 years ago, you'll see the reports were mostly on infectious diseases and others in hatcheries. With the emergence of salmon farming I would say really taking off about 20 years ago, now we're starting to see a lot of information, studies on diseases affecting salmon in net pens and other captive private aquaculture operations. In comparison, there's relatively very little done on diseases of wild salmonids.

Parasites, there have been parasite surveys, and even some pathogen surveys just documenting the mere presence or absence, and even less so the pathological changes at an individual level. But as far as population studies, impacts of diseases, infectious diseases, parasites, viruses, bacteria at a population level with salmonids has been very minimal. Other fishes, it's been done with herring in Europe and also Alaska, et cetera.

There's a lot of difficulties that we can -- we can get into talking about why particularly salmonids, wild salmonids are particularly difficult to investigate. Be that as it may, there's -- compared to other fields of fish diseases, there's very little on impacts of parasites and other infectious agents at a population level, let alone an individual level with salmonids.

Q Maybe I can pick up on the point you just made and without maybe having the overview level of answer, why is it so hard to obtain that information, why it has been hard to do the work vis-à-vis wild stocks.

DR. KENT: Sure. There's two reasons. One is that many of the methods that we use for investigating the impacts of disease and chronic infections, et cetera, at a population level require sampling the same population and knowing that it's the same population over multiple time periods. It's quite difficult with salmon. For example, they start out in freshwater as subpopulations. They may emerge out as smolts, then they would become one population. They go into the ocean, and tracking the same -- the identical population in the ocean is extremely difficult. And so what would happen would be is that you find a prevalence of a particular pathogen or lesion, et cetera, collect it in your own fish, then you look at sockeye salmon or another species of fish, whatever, a year later, how do you know, it would be very difficult to say that it's the identical population. And we're not just saying genetically, but actually the true population.

So that's the main -- one main challenge with salmonids.

Secondly, many of these species are protected, and therefore you don't have a -- you

have a limited number of samples that are available to you, and many of the methods that we use in fish diseases become more robust when we've got large sample sizes. So, for example, with herring, we can do a lot of these epidemiological investigations, because you can get thousands of fish from more or less the same population, and that's very difficult with salmon.

Q Is there a difference in the amount of research in the field as opposed to in the laboratory, relating to salmonids?

DR. KENT: Yes. Yes, sir, I just described the difficulties of reliability of doing this fieldwork, and so it does allow us to do -- on the lab side there's a lot more solid information, in my opinion, from lab studies, but it only pertains to the labs, lab work, and this is mostly -- most of these lab studies have been directed towards pathogens that one observed, and this is observed, associated with disease in captive fish.

So in a lab study there is more empirical data, but then relating these findings from a lab situation to what's going on in the actual field situation is difficult, because we know that that environmental -- fish being cold-blooded animals and living in water are very tied to environmental conditions within the water. And changes in environmental conditions, temperature, et cetera, can greatly affect the pathogenesis of an organism.

So if you do a confined study, a well-defined study in the lab under certain conditions under certain temperature, you have to apply that to what that pathogen is doing in the field with extreme caution.

Q Dr. Johnson, to pick up on that point, is it the case that a finding in the lab tells us something or only a limited -- limited understanding of what may be happening in ocean water.

DR. JOHNSON: You can learn many things from laboratory studies, but as Dr. Kent mentioned, it's very difficult to take -- to relate studies in the laboratory to what would happen in the population, in the wild population. For example, you can study things such as how pathogens invade the host. They have great detail in the laboratories. And you can study how the host, at least under

those laboratory conditions, responds to the pathogen.

One area that the laboratory work is, is that in general most of the laboratory studies we've done have been single pathogen studies. So we really haven't sort of gone to this concurrent infection. Most fish carry multiple pathogens. So that's another limitation. But so the laboratory studies have a place in investigations of salmon diseases, but they do not replace the sorts of field studies that Dr. Kent was talking about.

Q But there are challenges in studies that involve a particular stock and whether those conclusions apply more generally to the species?

DR. JOHNSON: There are stock-specific differences in susceptibility to some pathogens. Now, the -- and I would also say that within a stock there could also be family-specific differences. So when you have -- if you do a comparative susceptibility, or you -- susceptibility of a particular stock of chinook salmon to a pathogen, it's not necessarily comparable to another stock. I don't know if I've answered that very well, but...

Q No, I think I have your point. Is it the case that there is -- as I hear part of what you're describing, then there's really a challenge, although the laboratory may give insights about particular fish, or what the mechanism is on an individual level, one of the challenges is really then zooming back and having -- trying to have some understanding, whether you can get an understanding at a population level.

DR. JOHNSON: Yes, that is the major challenge, and an understanding in an environment, as Dr. Kent mentioned, that varies widely and has a significant impact on the fish and how they respond to these pathogens.

Q Dr. Kent, are there also challenges with respect to our understanding about the geographic distribution of pathogens, about what's going on in the marine environment, for example, two possibilities?

DR. KENT: Yes. these are both -- both challenges. They're not as, in my opinion, I would say not as difficult as the previous challenges that we just discussed. So basically it is correct, is when

you, if you did a survey on one population of the profile, of the suite of pathogens that may occur in these fish, you can't automatically apply that to other populations. There are geographic boundaries of pathogens. Often pathogens that are -- have intermediate hosts are defined by the distribution of their intermediate host, not by the -- not by the species of fish. For example, we have a very common pathogen down in Oregon and Washington called *Nanophyetus* that causes salmon poisoning in dogs. That's -- that's directed by the distribution of a snail, so it's not by distribution of salmonids. It will affect any salmonid, but it does not occur in B.C. because the snail host does not occur in B.C.

Q With respect to pathogens, I wonder if it's also the case that there's limited research with respect to whether there's a baseline, or a baseline understanding of endogenous pathogens in terms of their prevalence, in terms also of identifying those pathogens.

DR. KENT: Yes, that's true, and from personal experience and -- and I can speak more broadly, not just to say my situation but others, I feel this is important to obtain this baseline information. But this is not -- sometimes it's very difficult to get this type of work funded because it's not mechanistic, or as one would see it as not as much hypothesis driven, it's just data collection that could be used, that is a basic important foundation to determine if a change over time has occurred, if this pathogen occurred previously, or present.

For example, the pathogen distribution in -- occurs in wild fish before salmon farming. We don't have that information because the surveys weren't done, or in regions where salmon farming does not occur, that type of solid well-funded large studies on the distribution of pathogens. It's generally not done.

Q I wonder then if I, having covered a few aspects of this question with respect to the limitations on the research and the data, if you will, if I can move, Dr. Kent, to your report and in particular, Mr. Lunn, using Dr. Kent's report, at page 24. And I apologize, I didn't make the note that I have in front of me on the exhibit number.

MR. LUNN: That's 1449.
MR. MARTLAND: 1449, thank you.
Q On page 24, and we'll see this in a moment, but ultimately, Dr. Kent, if you could have a look indeed at the last sentence before the "Recommendations" subheading, and you express, after referring to Peterman:

> ...we cannot conclude that a specific pathogen is the major cause of demise to the Fraser River sockeye salmon. However, pathogens cannot be excluded at this time as adequate research on the impacts of disease on this population has not been conducted.

DR. KENT: That's correct.
Q Dr. Stephen, we'll come back to addressing this in more detail, but, Dr. Stephen, I wonder if I might ask you in relation to your report addressing hatchery disease interactions, could you comment on these limitations. Could you comment, as well, on the limitations that you identified in your report. Of course, the report speaks for itself, and, Mr Commissioner, some of what I'll do today, it doesn't -- and I hope not overly ambitious in trying to communicate all of the fine detail of these reports that are now in evidence before you, but that is a preface remark, Dr. Stephen.
DR. STEPHEN: Certainly. I can certainly reinforce the concerns or comments that Dr. Kent and Johnson did of the challenges of working with the population, and this is true for terrestrial wildlife as well as aquatic wildlife, of trying to understand the true distribution impact of diseases. There's a dearth in the literature for that, largely as Dr. Kent said, because most of our funding has been on mechanistic research, as opposed to population-based research.

From my risk assessment perspective for the report that I did, a critical element of risk is to identify that in fact has been exposure, and we've had very little work in general, looking at the exposure of free-ranging species to pathogens of particular sources, and part of that comes back to the challenges again, as Dr. Kent mentioned, of tracking populations, but also of tracking and finding the pathogen in the

environment.
I think another important deficit in the science side is the focus we've had has been on disease, as opposed to health. And the broader capacity for that population to be resilient and to thrive in the face of challenges like disease. So the fish health world has really been a fish disease world. So I think those are the main science concerns.
From our report's perspective there was some challenges in being able to validate local data, so our report had to be somewhat broad and generic because of the time constraints that was imposed upon us.
And finally, the last one is that we don't really have systematic surveillance, in my perspective, of hatchery reared and wild fish. We have periodic surveys. We have some surveillance for specific pathogens, but overall health surveillance is lacking. So our understanding of even the distribution and abundance within the full populations is challenging at this time.

Q Dr. Johnson, you made a point with respect to co-infection, Dr. Stephen just described a disease as opposed to health kind of a contrast, I suppose. Could you comment on whether the research -- to some extent does the research or does our understanding reflect a focus on specific pathogens as opposed to asking sort of stepping back kind of questions about co-infection, about the interplay of different factors.

DR. JOHNSON: I think to date the vast majority of the research that's been done on diseases of fish has been related to a specific pathogen. I cannot think of any papers off the top of my head where they've actually studied multiple infections in fish.

Q Thank you. Dr. Kent, I'd like to move back to your report. Your report, again which is now in evidence, offers a subjective risk assessment with respect to a variety of pathogens and diseases. And before going into discussing at least some of those specific pathogens, I'd like to spend a few minutes with respect to how you went about your analysis. And I think a pretty logical way to start that discussion is asking you about how you approached the concept of risk in your report. So

if you could comment in the context of this report, which you were asked to do, how you went about defining and using the concept of risk in your report.

DR. KENT: Sure. And I think there's somewhere in my report we could find that early on.

Q Probably page 2, at least in one part.

DR. KENT: Okay.

Q If that's helpful to you to have in front of you.

DR. KENT: Sure. But I can speak without seeing this. So in preparing this report, based on my scope of work, I was told to provide a ranking system on the potential infectious agents as to how they could impact sockeye. So this would be a ranking of impacts, and I basically use this -- in this context I use the term "risk". And Dr. Stephen may want to expand in this as a -- in the field of epidemiology, risk may mean something slightly different.

So we're talking about risk as basically potential for impact, and we use that interchangeably in my particular report. The use of the term risk in Dr. Stephen's and other reports may be used a bit differently.

And as I outline in here, basically a high risk pathogen would be one that is known to be virulent or pathogenic to salmon in general, and likely pathogenic or documentedly pathogenic, highly pathogenic to sockeye. So that would be one criteria. And the second criteria to fall within the high risk scenario would be as a likely scenario where sockeye salmon in B.C. in general and Fraser River sockeye in specific would be exposed or infected by that. Moderate would be -- low, I'll just talk about low risk. Low risk is the opposite. Documented or to be, or based on -- documented or suspected to be low, not very virulent, or very unlikely to be infecting sockeye salmon, particularly Fraser River sockeye salmon. And then the midrange would be intermediate to that.

And certainly there's a lot of subjectivity in that. These are my -- my rankings. I see that it doesn't fall, that much of the pathogens that I've ranked in the high risk area does not differ much from other recent reports on this -- on the Fraser River sockeye, but I did not basically use

these other reports to come up with my ranking. These are mine, done independently. It just clicks it out, well, it's just the way it is, is that it actually matches up with some of these other reports more or less.

Q Dr. Stephen, Dr. Kent alluded to you perhaps having a different understanding of the meaning of risk in epidemiology. Could you comment on that as well as how that concept of risk was used for your report?

DR. STEPHEN: Well, it's not just in epidemiology, per se, but also in a lot of our environmental impact work, as well as in international trade, risk assessment is fairly well defined as having a few components. One being in fact understanding the acceptable threshold, to judge against your findings to determine if something is acceptable or not. Secondly, to have an adequate or certainly complete understanding of the hazards, in this case the infectious agents that reside in the population, or to which your population of concern would be exposed. The third level, then, of course would be exposure to actually be able to document that the population of concern has been exposed to that hazard. And then finally the capacity for any steps, whether they be management or legislative or otherwise to mitigate against those risks.

So we followed that framework for our risk assessment and tried to accumulate information and data around each of those four points to determine if in fact risk could be measured in the hatchery scenario.

Q I'd like to turn, please, Dr. Kent back to your report and to first of all on the very first page of the report after, I think, the preface, which is Roman numeral lower case "i", and you'll see on the second or third line, and I'll read it out:

> At present, there are no direct links between a specific pathogen and sockeye salmon survival at a population level in British Columbia.

You make a comment, and I'll flip on a few pages to page 1 to read this.

DR. KENT: Yeah, I agree with that. I do agree with

that.
Q I thought you might.
DR. KENT: Yes.
Q Page 1 we'll see that after citing a number of articles, about seven or eight lines down, you write:

> ...there have been only a few infectious diseases that have been shown or implicated to cause significant mortality in wild salmon in British Columbia...

DR. KENT: That's correct.
Q Is it the case if you were describing your research or findings to a non-scientist or a layperson, is there a smoking gun here?
DR. KENT: In my opinion, I don't see a smoking gun for the present situation. As I said, there are some pathogens like the *Ichthyophthirius multifiliis* that has been described associated with pre-spawning mortality in sockeye up in the Babine system, et cetera. So there's specific examples where -- where there is, quote, a smoking gun in a particular population. But there at present there is no -- there's no scenario like that for -- for the populations of sockeye salmon that we're looking at in this particular exercise.
Q I'll paraphrase to ask this question, but at one level I understand you to really suggest that the conclusion here, if you will, is that the first, rather than the second among these two examples, the conclusion I read you as reaching is that the evidence doesn't show this, but that's different than the stronger conclusion of saying it's not happening. We know that's not the case.
DR. KENT: It's option one, yes, that the evidence that there is -- the evidence does not show this, based on the data that we have. No. And so therefore we cannot say that there is not an infectious agent, or other disease phenomenon, and that's kind of an important role in the survival of sockeye salmon, and we just do not have any hard evidence to support that at this time.
Q And in the absence of that evidence, how much comfort do you take from it not having been proved, per se?
DR. KENT: What do you mean, as (indiscernible -

overlapping speakers).
Q (Indiscernible - overlapping speakers). Do you have a concern that this may be happening but it's not been proven or documented, per se.
DR. KENT: Yes. I think it's worthy of investigation. Simply to not move forward on investigations on the impacts of diseases on salmon, sockeye salmon, because we do not have any firm evidence at this time would not be prudent to do that. So does that clarify my answer?
Q I think it does. Dr. Johnson, do you have an answer on that question or on that point?
DR. JOHNSON: I would agree with Dr. Kent on that point. But I also suggested there still is a need for us to know exactly what is happening with respect to the pathogens that we already know exist in sockeye salmon, because I don't feel that that's been adequately addressed. So we know that these animals evolved with a variety of pathogens. They could become -- they could carry these pathogens. They can go through their life quite happily carrying these pathogens without disease. We don't know what triggers disease.

So I think that if there is to be more work done, it needs to both consider those things that we know, and the possibility that there is something new.
Q You make a distinction between carrying a pathogen, but it's not at the point of being a fatal or a disease even, for that matter. That's an important distinction. I wonder if there are misconceptions that you come across with respect to disease. Do people that you -- whether that's within the Department or perhaps even more broadly, are there misunderstandings on how disease operates for salmon?
DR. JOHNSON: Well, I don't think it's just for salmon. It's for all animals and human beings, as well. That it's not uncommon to find animals or fish within a population that carry pathogens and they show no signs of disease. However, given the appropriate environment conditions and that, what can become a natural association with a pathogen can become unbalanced and you can see the development of disease. So I guess the take-home message is that the presence of pathogens does not necessarily mean that there will be a disease or a

disease outbreak within an individual or within a population.

Q Dr. Kent, your report, I think only touches on this briefly. But there's certainly been public concern with respect to the prospect or possibility of the arrival in this province of ISA or infectious salmon anaemia, in particular. I'd appreciate knowing of work you've done on ISAV and also on any comments you have to make with respect to the risk it may present, or the effect it may have if it does arrive for Fraser sockeye.

DR. KENT: I have not done -- I've essentially done no research on ISA virus, infectious salmon anaemia virus. I worked on another virus, the salmon leukemia virus that was associated with a disease that in the fish farm community referred to it as marine anaemia, so there's been some confusion between ISA virus, which has been called marine anaemia in other parts of the word, and Dr. MacWilliams could probably expand on that, because she did a lot of work on that.

So as far as what we refer to, particularly the ISA virus, a well-defined virus and well-defined disease, to my knowledge has never occurred in British Columbia. It occurs in other parts of the world and can cause a serious disease in salmonid fishes. But to my knowledge at present, and reviewing the documents that were -- that I had an opportunity to review, I see no -- and testing for ISA virus, I've seen none of that. But I think Dr. MacWilliams can expand on that much more than I can.

Q Dr. MacWilliams, I'd ask you to do that, please.

DR. MacWILLIAMS: Could you repeat the question, please.

Q Sure. I'm looking to have -- well, let me in fact ask you to pick up on a point that was just made. And with respect to ISAV and marine anaemia, are they the same thing or different?

DR. MacWILLIAMS: No, they're not.

Q Could you explain that, please.

DR. MacWILLIAMS: I can't actually tell you much about marine anaemia because I've never worked on that one, and I haven't seen it or diagnosed it.

Q And you've worked on ISAV, then?

DR. MacWILLIAMS: Yes, I did that during my Master's thesis work. And infectious anaemia virus is --

has just been shown to cause natural infections in marine farmed Atlantic salmon. Under experimental conditions they have -- certain labs, including mine, have been able to experimentally infect using a high dose of a very pathogenic strain of the virus and cause disease in other species. In my case it was rainbow trout or Oncorhynchus genus.

And but work done on Pacific salmon has shown that Pacific salmon are relatively resistant to the disease. You can infect them with a high dose of a strain in very unnatural conditions in a laboratory, and you can -- but most Pacific salmon species, they weren't able to cause disease. They were able to just have application of the virus, but the fish did not actually get sick.

So it is important to note that Atlantic salmon are the only species that have ever shown natural infection in a wild environment.

Q You refer to work having been done for Pacific salmon. Do you know if that includes sockeye particularly, or which species were used for that work?

DR. MacWILLIAMS: I can't confirm sockeye has been worked on, no.

Q Okay. Let me move, Dr. Kent, I'd like to have Mr. Lunn bring up pages 19 and 20 of your report. And just to first, we've made a correction to the second of those two pages, page 20, where I suppose something was overbilled, *Cryptobia salmositica* was given a "Severe" but that was really a typo. Dr. Kent, you in your report, in the text of your report placed it in the moderate category.

DR. KENT: Yes, that's correct.

Q All right. And we've entered a document to that effect. You've also described the risk level that you've used for this report. It is, and I think your answers suggest that you are being modest in acknowledging that there's some limitations or there's an in-built subjectivity to this kind of a ranking system. It's very helpful as a talking point but of course this can't be the final word on the risk level forever and ever with respect to Fraser sockeye; is that the case?

DR. KENT: Yes, certainly.

Q Are there challenges to ranking chronic or sub-

lethal diseases?

DR. KENT: Yes. The challenges would be, I think I can kind of follow up on what Dr. Johnson was just talking about. I would only see three categories of the impacts of pathogens. One would be basically almost commensal, with very little impact at the host level and maybe no, often no impact at a population level. So talking about the host and individual organism then, we're really -- we're not too concerned about one salmon dying from a disease. We're talking about impacts at the population level. So let's talk about it at both of those levels.

So you could have no impact at a population level, and at a host level or an individual level and a population, and you could have some that are -- that may be an acute virulent disease that would be -- cause a severe impact on an individual level, but the prevalence of that pathogen is so low that it's not really impacting the population.

Let's talk about chronic diseases. So as many of these chronic infections, parasites often fall into this, the chronic diseases like bacterial kidney disease, many animals are infected at a low level with these, or if you look at them histologically, you did a pathology examination, you would find that, yes, there are lesions. How is that, but the fish appears totally healthy, and that fish may live its entire life healthy.

But there can be other, and this is the line of work that we do in our lab is looking at other endpoints other than just the fish appearing morbid. Do they grow, do these chronic infections slow their growth or affect smoltification? Other studies look at the effects of chronic infections on fecundity, the number of eggs that are produced, so how it affects spawning.

So there's a lot of these indirect impacts of these chronic infections that if they are prevalent can impact a fish at a population level, but that an individual level they seem like they're not really causing much problem, because the fish would appear totally normal.

Was that probably it's a kind of a convoluted answer, but that's some of the challenges of chronic infections is that they may have other --

the term "chronic", that means the fish is going to be infected with this particular pathogen its entire life and maybe at some stage in its life, it could actually have an impact on its survival.

Q Dr. Johnson.

DR. JOHNSON: I would like to just add that with respect to a chronic infection, a good example from sockeye salmon may be *Myxobolus arcticus*, which is a parasite which resides in the brain of most if not all Fraser River sockeye salmon.

Q Mm-hmm.

DR. JOHNSON: And studies out of Alaska done many years ago have shown that in situations where this parasite in the brain is very abundant, although the fish look normally healthy outside, they do see that there's some level of reduced swimming performance. So that would be, I think, a good example of a chronic disease of sockeye salmon.

And just to add a bit onto Mike's commensals, it could be commensal or opportunistic. There are things within the environment that normally don't cause disease in fish, which under -- given bad enough conditions for the fish can become a problem, and I can't think of a good example offhand, but I would say probably some of the fungi that occur naturally within the environment.

Q What does "commensal" mean?

DR. JOHNSON: Well, I would say commensal is living in association with but not -- I don't know the proper parasitilogical definition offhand, but probably living in association with but not necessarily causing a great deal of harm. I mean, just through the association there is some harm or damage or some cost to the host. So it's not a benign relationship.

DR. KENT: Yeah. Well, I guess we would often think of commensals as living happily together, you know, and basically a bacteria in our gastrointestinal tract would be a good example. They're living off some of our nutrients that they're considered -- that we're eating, but at the same time they're not causing severe disease. And that's what Dr. Johnson was trying to think of an example, there's many examples in human medicine. Many of us are aware of the infection called *Giardia*, giardiasis, where lots of people are infected with it, and basically are totally normal. So those people

with that particular organism the *Giardia* organism that you get when you're camping, et cetera, would be a commensal. And then under certain circumstances, many of them are unknown, the genetic predisposition of that person, or having some other underlying stress or disease, they could flip over it and become a pathogen and actually cause detriment to the host.

Q Dr. Kent, is there, when you describe these limitations on the research and the knowledge -- and our understanding on some pathogens, is there a potential that one of these that may be put in a low risk category here is put in the low risk because of the lack of information about it, as opposed to saying that you've reached a conclusion that's simply not of concern.

DR. KENT: It's the lack of information, and I could just kind of pick some of these low -- I'm just looking right off the top of these tables, like VEN, the viral erythrocytic necrosis virus. I don't -- that's been known for a long time. It's supposed to cause -- I mean, it's recognized as a pathogen in herring. Salmonids are susceptible. My work with salmonids, I've never seen any severe disease caused by it, but no one has been out looking at -- to my knowledge, and maybe Dr. Johnson and others can expand on that.

But doing blood smears on wild-caught sockeye and, I mean, we're doing that and this infects the blood cells. And suddenly you saw a very high prevalence and a severe -- high prevalence, lots of animals infected, and then it's a severe infection, that would mean high levels of erythrocyte blood cells infected, you'd say well, this would jump out of the low category and be put into the -- to the high category. And what I mean by high category, it's not proven to be that, and it would be high on the priority to do further investigations on what that particular pathogen was doing to the host at -- both at an individual level and at a population level.

So a lot of these low organisms are ones that are not known, are not documented to be virulent, but that doesn't mean that they have been shown not to be, with experimental studies, that they have not been empirically shown not to cause disease.

And particularly as other colleagues have mentioned, under a certain environment, because then you'd want to be more particularly interested in my understanding is what's going on in the marine environment. So you'd have to do these challenge studies in the lab with a marine -- a marine phase fish, and sockeye. And frankly, because sockeye salmon are not reared a lot in captivity, most of the work done in lab studies have been done with other species than sockeye salmon.

Q Dr. Johnson, you nod to that last point at least?

DR. JOHNSON: Yes, I agree with that, and I think Mike's point that even these pathogens which are in his low risk category, under the appropriate environmental condition, food limitation, or whatever, has the potential to cause disease within an individual and possibly within populations.

Q Maybe I can now move through some of the specific, and I'll be addressing, I think there's a total of six pathogens or diseases Dr. Kent, that you ascribed or put in the high risk category; is that right?

DR. KENT: I can't recall, but I mean that sounds about right, as far as the number that I put into that category.

Q Okay. Well, hopefully my counting was okay. Let's move through with first of all, IHN.

DR. KENT: Okay.

Q Infectious hematopoetic necrosis virus?

DR. KENT: Yes.

Q And for all of these, I'll just simply add what I won't be doing here is trying to have you explain the life stage, where whether in marine or freshwater, where these pathogens may be located or found, and so on. That's set out in your report. I wonder if I might pick up on the question of IHN by using, Mr. Lunn, a different document - so we can perhaps keep this on deck, I'll certainly be coming back - number 11 on our list of documents.

And I think, Dr. Johnson, I may in fact ask these questions of you. You'll see Kyle Garver's name is there. He's coming later this week. But he works for you, Dr. Johnson, and I may be taking a shortcut, but I'd like to ask you. I take it

you're familiar with this document, and indeed may have been involved in it?
DR. JOHNSON: Yes, I'm familiar with the document and I was somewhat involved with it.
Q All right. What is this document in brief?
DR. JOHNSON: This is a document that Kyle was asked to put together for a workshop that was held by the Pacific Salmon Commission. I didn't attend the workshop myself. But he was asked to sort of discuss what pathogens are known to affect sockeye salmon and to provide a bit of insight into some of the longer-term studies that they've been doing on sockeye salmon for specific pathogens.
Q It says at the top: "Hypothesis: Diseases in freshwater and marine systems are an important contributor to the Fraser sockeye situation". That's really posing the question as opposed to giving the answer. Is that a fair description?
DR. JOHNSON: Well, I think that this is providing information that could be related to that hypothesis.
MR. MARTLAND: I'd like to ask this be marked as the next exhibit, please.
THE REGISTRAR: Exhibit 1456.

EXHIBIT 1456: Garver, Hypothesis: Diseases in freshwater and marine systems are an important contributor to the Fraser sockeye situation, June 2010

MR. MARTLAND:
Q If we look at page 3, we're speaking about IHNV prevalence rates. And I'd like to, if Mr. Lunn's able to bring up those two graphs that are in the figure on the upper left-hand side. He's very adept at zooming in and out, so I know we'll have those there. With respect to those prevalence rates that are set out, first of all, Weaver Creek and Nadina River are both spawning channels; is that right?
DR. JOHNSON: I know that Weaver is, and, yeah, Nadina is also a spawning channel.
Q All right. And Dr. MacWilliams, I'll just confirm, do I have that right?
DR. MacWILLIAMS: That's correct.
Q Thank you. This document suggests first of all that we see very different bars, if you will,

reflecting the different years, and the prevalence rates over time of IHNV. That seems to suggest, first of all, significant variability year-to-year; is that fair?

DR. JOHNSON: Yes. The graphs do demonstrate the highest amount of variability between year-to-year. The other thing these graphs demonstrate is that there's not always a good relationship between the prevalence of IHNV in adults and the -- in the fry that came from those adults. So it just shows that it's very difficult to predict, based on IHN levels in the adults whether there'll be any IHNV detected in the fry.

Q It also would seem to be, and I appreciate these may be two snapshots as opposed to running film, but it would seem to be that from these snapshots of understandings we see potentially very different pictures in a given year as between those two spawning channels. I think the best illustration is the earliest years, which would be about 1988 or so.

DR. JOHNSON: Yes.

Q Quite high levels at Weaver Creek and relatively lower at Nadina.

DR. JOHNSON: Yes. And I think that this is what you'd expect to find if you were to go out and monitor wild populations, a high level of variability depending on where you collected the fish, and very high levels of variability between years.

Q And at a broad level would you offer your view on what sorts of insights or broader conclusions we can draw from these, I used the word "snapshots". I don't know if you'd agree that's the way to look at this. But is this something that we can transpose or extrapolate out to a broader understanding of Fraser sockeye?

DR. JOHNSON: As I said, I think this really points out a lot about the actual difficulties that we would face if we tried to do a more complete assessment of Fraser River fish, rather than -- it shows that based on the way this monitoring program has been conducted, is that we can't predict whether the fry will have high or low levels of IHNV based on the adults that have returned, their condition. So I think it's better to be used as a point, and I think the point that Kyle was making in this paper was that there's high level of variability

between these two systems, and a high level of variability between years just illustrates how difficult it is going to be to get a handle on pathogen loads within the various stocks of Fraser River sockeye salmon.

Q And I wonder to complete this picture with respect to IHNV, there's a new document that was not on our list of documents, but it was received in the recent production by Canada, the CAN number is the Ringtail number, it's described from Canada's production 490137. And in fact, Dr. Johnson, this morning I asked you, I showed you this document just to confirm, and I think what you'll see, and I'll -- Mr. Lunn will be finding that document in a moment. But as he goes to it, I think what it may give us is the IHN prevalence -- IHNV prevalence rates, again for Weaver and Nadina, but also adding the more recent results, including from 2010.

DR. JOHNSON: And I think if I remember -- oh, there's the graph. Sorry. Yes. This is the actual data on which that original document was -- the original document was actually written from this data.

Q Mm-hmm.

DR. JOHNSON: Again what it shows is that within any of these systems, including the Okanagan River, which of course isn't part of the Fraser River, but the prevalence of IHN in adult sockeye can range widely from, you know, zero percent up to, I don't know, what's the highest, 52 percent in some years. And there's really no discernible pattern over time.

Q Is that an alarming number, 52 percent, or does that simply -- we need to -- it strikes me that the most recent number is the highest. But it doesn't, as you suggested, perhaps it just simply confirms the unpredictability.

DR. JOHNSON: 1987 had 38 percent. I think that all of these field studies are going to be somewhat influenced by the time that when these samples were collected. So, I mean, these studies have been done year after year. They go on a field trip to the river, and the field trip is, you know, timed to try to capture the same portion of the run every year. But basically some years the fish are early, some years they're late, and so

you may be capturing -- it's not to say that these prevalences are set in stone. So if you go and the fish have just arrived on the spawning grounds, you may find ten percent. If you go back after they've spawned, or just prior to their spawning, that could have increased, or it could have decreased, if those individuals that are carrying the virus fell out of the population.

So I think that there is a bit more variability there in with respect to what time these fish are actually sampled.

MR. MARTLAND: Before I forget to do it, Mr. Registrar, if I might ask this be marked as the next exhibit, please.

THE REGISTRAR: Exhibit 1457.

EXHIBIT 1457: IHNV prevalence rates in Fraser River sockeye salmon data, undated

DR. KENT: I could expand on what Dr. Johnson just said. And we're conducting a study on pre-spawning mortality in chinook salmon on the Willamette River down in Oregon, and we see dramatic differences in pathogen burden based on how long the fish have been in the river, and therefore that reflected on that would be what time of the season en-route migration or even at -- that the fish were examined.

So I just would have to agree with what he was saying there, that not only variation in year, these variations could be described by geographic differences, but also I think that's a very important point, about the time of the run that the fish are looked at. And you say, well, we're going to try to deal with that situation by collecting the fish on September 1st, or whatever every year, but then the problem is the runs vary from year to year. And so it may be late in the run or early in the run, depending on the year.

Q Is it the case, Dr. Kent, that not much is known about -- we have some information from Weaver and Nadina, but beyond that we have an absence of information or data about other sockeye spawning areas?

DR. KENT: That's my understanding. I think others from DFO might be able to expand on that, but there is limitations, that's one concern, but then

also if we get back to the marine environment, there's very limited information on how -- we're talking about the impacts of IHN on fry fish and relationship to spawning adults. I mean, maybe take a step back a little bit, is that the virus is known to be maternally transmitted, and that's why there's a lot of work looking at correlations between disease in the fry of the following year correlating with brood stock. As Dr. Johnson pointed out, these correlations do not -- do not hold up, and this has been well-recognized for a long time.

I understand that there is some new information on well, basically what we -- if we talk about IHN as a potential impact on the marine -- fish as they are in the marine phase, there's been some transmission work that was run by Garth Traxler, a former DFO scientist, and others showing that the larger sockeye salmon when they're in the marine environment are much less susceptible to the IHN virus. But I understand that there's -- that there's some variability in the strains of IHN and that some of them may be more pathogenic to the marine phase salmon. But that's new information that's not been published, and so I can't really expand much more on that in that area.

Q Dr. Johnson, yes.

DR. JOHNSON: Yes, I'd like to just make one point there. There's only, as I understand, one genotype of IHN in sockeye salmon in British Columbia. These other studies which have used these other genotypes was in a laboratory study, so these are not naturally occurring genotypes. I may stand corrected on that. There also has been some studies on Alberni Inlet sockeye salmon, on IHN studies there. But those have been somewhat limited, and were conducted quite a while ago.

Q If we move back to the Technical Report 1, you'll see in the high risk notation is given, if we move down that page a little, under "Bacteria" to "*Vibrio*", and under that "*Aeromonas*", which I mispronounced earlier, which causes furunculosis. Dr. Kent, do you have any comments beyond what's set out in your report about those two bacteria and their potential to have a significant effect on Fraser sockeye?

DR. KENT: I put *Vibrio Anguillarum*, cause of vibriosis in the high risk category, because -- potentially high risk category, because we know that it's ubiquitous in the marine environment and under certain conditions it can be highly pathogenic. To my knowledge there's been very little work on survey of *Vibrio* in post-smolt sockeye, that's sockeye that have just recently entered seawater. Other species of salmonids they have found it in.

So it is one of potential -- it's generally thought in the scientific community that *Vibrio* is associated with environmental -- the prevalence of the bacterium in the ocean is associated with environmental conditions, and then the fish being stressed. Those two combinations together would result in a high level of disease in them. And fish are going through a fair amount of stress when they first go from seawater -- freshwater to seawater as smolts. So that's why I put that one in the high category.

Aeromonas salmonicida, the cause of furunculosis, well-recognized as an important disease in captive fishes, and highly pathogenic, that's why we would put it, and, you know, that would be one that would, if it occurred, if the pathogen occurred in sockeye salmon, in my opinion, it would be likely to cause significant disease.

I'm not aware of any experimental studies done with sockeye with this bacterium, but I'm -- based on what we know on the historical specificity and ability to cause severe disease in a number of salmonid species, I would suspect that sockeye salmon would be highly susceptible to it.

Q Dr. Johnson.

DR. JOHNSON: I'd just like to add a little there. It's not that people haven't wanted to do experiments with sockeye salmon, they just happen to be extremely difficult to maintain in the laboratory. And that's a key thing with the laboratory studies is that when you're taking these animals, a wild animal, out of their natural environment, putting them into the laboratory, introducing them to a foreign food source, then you've got to wonder what -- what effect is this having on their stress level and how does this impact your results.

I guess the other problem with sockeye is they often have IHN, which when you bring them into the laboratory can cause problems in the laboratory environment, just simply through the stress of them being taken from the river and then contained in tanks.

Q Let me turn now to BKD, if you see at the bottom of that page 19, *Renibacterium salmoninarum*, which I think I read as *R. sal*, is that shorthand for --

DR. KENT: Sure, that's fine.

Q All right. That's going to be easier for me. So I may use that and perhaps shouldn't be using BKD. which is in fact the disease caused by that bacteria, if I have that right.

DR. KENT: That's right. The disease is called bacterial kidney disease, and we refer to it as BKD, and the bacterium that causes it is *R. sal*.

Q In your report you make reference to sockeye being particularly vulnerable to *R. sal*, and as it causing acute to chronic severe systemic disease which can result in death between weeks and months following infection.

DR. KENT: That's correct.

Q Dr. MacWilliams, you have dealt with BKD in the context of work on salmon enhancement facilities. I may return to discussing that more when we move to Dr. Stephen's report, as well. Do you have comments on the immunological impact and the increasing disease susceptibility in surviving fish from *R. sal*?

DR. MacWILLIAMS: In my experience *Renibacterium* more likely causes a chronic progressive lifelong infection that gets worse over time. The bacteria is very slow growing in culture and in my experience it is also slow growing within a population from the exposure and infection, it can take months before you'll actually see any clinical signs of disease with this pathogen. When you do see signs of disease it can be causing acute morality at that point, but the chronic, slow developing nature is part of this pathogen.

I'm, sorry, I forget the rest of the question.

Q No, that was -- that covers me some distance. I wonder if I could ask --

DR. MacWILLIAMS: Oh, sorry.

Q Go ahead.

DR. MacWILLIAMS: I remember. Part of it also is because *Renibacterium* actually infects the host's immune cells, having this as a concurrent -- or a concurrent infection can make any animal, any fish more susceptible to other diseases, because it's kind of modulating its immune response.

Q And you in your answer described it from your experience. Maybe you could just help us understand, where is it that you're seeing *R. sal*, and what's the context? How is it, can be seen, so to speak?

DR. MacWILLIAMS: Well, it's an endemic pathogen in British Columbia in all Pacific salmon species. So we pretty much see it everywhere.

Q And is it in the context of work on hatcheries and salmon enhancement facilities that you were coming across it in your work?

DR. MacWILLIAMS: Yes, we see it in enhancement hatcheries, we see it in the research stocks that are derived from wild populations, we see it in wild fish kills, oftentimes it's detected as an incidental finding if there is another cause of disease, but it can be a primary pathogen, as well.

Q Mr. Lunn, if we move back to Dr. Kent's report in about the middle of page 20, under the "Protozoa", Dr. Kent, you list *Ich*, which you've said in full, and I won't try and do so, but it's also known as white spot disease. We see that is listed as a high risk pathogen. I think you indeed singled it out earlier, and I wonder whether is that pathogen a particular concern for Fraser sockeye?

DR. KENT: It would be a concern --

Q I'm sorry, and your microphone, thank you.

DR. KENT: I'm sorry. It would be a particular concern as a cause of en-route and pre-spawning mortality, adult fish coming back and it's been documented by Dr. Traxler and a few others to actually be associated with severe disease in fish that have returned to freshwater spawn. It would not be a problem in the marine environment at all, because actually that's a treatment that they use for treating this parasite is salt, so this would not even be on the radar as far as a cause of disease in the marine environment. But certainly when waters are the right temperature, around 15 to 20 degrees, that this parasite can cause devastating

mortality when fish are in a rather confined situation such as when they come back into spawn and spawning channels in close proximity to each other.

MR. MARTLAND: Mr. Commissioner, we're getting close to the break time. I wonder if I might close off on the last of the six high risk category pathogens and then suggest we move to break, if that's agreeable.

Q With respect, Dr. Kent, if I could take you to page 15 of your report, and the second and third paragraphs are discussing *Parvicapsula*, which is again listed in the high risk category. We see under that "Risk. High" paragraph, you make the comment that:

> ...this is one of the few pathogens that have been documented to occur in a high prevalence in Fraser River sockeye salmon.

Then just to step back one paragraph, you make the comment that:

> DFO had an active research program investigating this parasite in sockeye salmon until around 2003/2004. At this time, sea lice became a major concern in the Province, and fish health research efforts were diverted from [*Parvicapsula*] to study sea lice.

DR. KENT: That's correct.

Q Is there -- when there's a diversion of efforts, is there a sense in which that may reflect whether it's public interest or political interest, or the allure or appeal of addressing particular concerns? Is that part of in your view what's...

DR. KENT: All of the above, and I can say with working for 12 years -- 11 years with DFO, and there's a frustration with scientists in that they'll be working on a project and it does not come to completion or significant progress because of pressure from political reasons and others that scientists - when I was there, maybe things have changed now - are directed to with their limited resources redirect their resources to the, if I should say, the disease of the day that has become

popularized in the media. And so that that's my -- what I, as you see here, this is I conducted a one-day interview in December with various scientists at DFO and this is my interpretation from the interview with Dr. Jones on why the work was not continued with *Parvicapsula*. They had some excellent work going on with that and then I saw that it didn't continue on from the early -- from about ten years ago.

Q Dr. Johnson, I wouldn't have thought this to be the case, but do some fish diseases have sex appeal? Do sea lice or their...

DR. JOHNSON: Do sea lice have sex appeal? No. I'm just going to add a little to that. There have been papers published after that and Dave Patterson and that have continued to work on *Parvicapsula*, especially as how it affects host physiology. So I wouldn't say that DFO was out of it. Simon had a program where they were observing for it in rivers. They more they looked, the more they found. And at that time sea lice became a concern as expressed by a variety of different groups within British Columbia.

I guess in support of my group, one of our main roles is to provide science-based advice for managers. And so we have to be somewhat responsible to questions which are posed to managers, and that can have an impact on, you know, longer term research programs.

So in the case of when sea lice were identified as a potential issue on wild fish, there was money made available that was outside of our program, and every people, such as Simon and myself when I came, took advantage of that money to provide this advice.

Q You mentioned Simon, I'll just for the sake of the record confirm you're speaking about Simon Jones.

DR. JOHNSON: Yes, Dr. Jones, sorry.

MR. MARTLAND: I don't mind the informal, but I just want to be clear who we're speaking about. Mr. Commissioner, if I might suggest we move to the break.

THE COMMISSIONER: Mr. Martland, just before we do, I wonder if I could just ask just a couple of brief questions following on the answers that the panel has given this morning.

QUESTIONS BY THE COMMISSIONER:

Q And this may be a complete non sequitur and you can certainly be frank with me and tell me if I'm in another realm. But in the human or mammal world or animal world, we hear of disease sweeping through a population, it might be SARS or some other kind of let's call it epidemic that comes and goes. And we hear from the health officials that we're okay now: it came, we've dealt with it, it's gone. Within the populations of fish that you're addressing, could it be that a disease would come and go in that way to a population without the scientists being aware of that happening, or would there always be telltale signs of that kind of experience having happened, so that you could then determine whether more research needs to be done.

The other question I have for you is whether the research you've been explaining, that needs to be done, would have to be done on all salmonids in order to make some sense out of what is happening to a particular population, for example, sockeye.

DR. KENT: I can respond, and then maybe my colleagues might want to add to it, and particularly your first question, Mr. Commissioner. You bring a very -- the analogy certainly could take place where a disease could sweep through a population. In humans we could almost -- it's more confined and generally we don't -- so that humans are a little bit more confined. But the big problem, the big difference would be is if it's a disease like an acute viral disease, devastating viral disease swept through a population, we'd have dying humans, or sick humans at the hospital that we could document this.

Unfortunately in the ocean when a fish dies, it just disappears. And so we don't have the opportunity, particularly with salmonids in the ocean, to find dying fish. They're just not available. We have these phenomena like the VHS virus, there's a viral disease that has swept through the Great Lakes. In a confined lake they're able to document actually dying fish. Dying sockeye salmon out in the ocean would be very difficult to encounter. In fact, you could have, in my opinion, you could have conceivably

very large numbers of fish dying, due to a new viral disease or other pathogenic phenomenon, and not detecting it. That's my -- like, that's basically my thoughts on that, and probably my colleagues might have something else.

DR. JOHNSON: No, I generally agree with what Dr. Kent just said. There have been occasional IHNV outbreaks and other parasite outbreaks in sockeye stocks, which when they've occurred in freshwater and especially occurred in association with spawning channels where we have people actually on the ground, that they've been actually able to document them. But even in the freshwater environment when we have, you know, the Fraser River watershed the size of Germany, there's a lot of places which are terribly inaccessible, and we simply don't have the people on the ground to make those sorts of observations.

DR. STEPHEN: I think, Mr. Commissioner, you've brought up a very important point to recognize that there are analogies to things like SARS. And I think I'd get you to reflect on mad cow disease, bird flu, and wearing my public health hat, our capacity to predict precisely when a human epidemic is coming is pretty bad. I mean, BSE, mad cow was going to wipe us all out, if you recall, then we had very few human cases. Even our early models of HIV were very wrong, and this is in a situation where we have excellent data on a large number of people, with tests and all those sorts of things, and the public health response is beginning to abandon this concept of prediction to this concept of readiness and resilience, and how do we in fact forecast the unforecastable in an area we have a lot of money and a lot of data.

So when we add the challenges that have been brought up this morning with salmon, our capacity to identify specifically it will be this stream this year is very limited. To find general causes that might make a population more susceptible to disease, we can talk in those generalities. But prediction is very challenging in a population that is under very little oversight and watching.

DR. JOHNSON: And I'd then follow up on your second question, Mr. Commissioner. So we can learn lots from research done on other salmonid species. So we can learn a lot of very general things about

fish. We can learn what is the nature of their stress response, how do they respond to elevated water temperatures. But we would need to do these particular studies on sockeye salmon to actually set the limits of their tolerance. So I think we could learn lots and we can learn lots about how even from Atlantic salmon, how they respond to pathogens, what immune system functions are up-regulated when they're challenged with BKD. And those should probably be the same in sockeye salmon. So we can learn very basic things. But for a particular -- for sockeye salmon and even probably for different populations of sockeye salmon, we would really need to actually do these studies on those fish.

THE COMMISSIONER: Thank you very much, Mr. Martland, and thanks to the panel for those answers. Thank you.

MR. MARTLAND: I wonder if I might suggest if we're able to do a ten-minute break to hold to our schedule, I'd appreciate that. Thank you.

THE COMMISSIONER: Certainly, thank you.

THE REGISTRAR: The hearing will now recess for ten minutes.

(PROCEEDINGS ADJOURNED FOR MORNING RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: Hearing is now resumed.

EXAMINATION BY MR. MARTLAND, continuing:

Q Thank you. Dr. Kent, we were looking through your report and I don't have any particular part to go to within the report, but I wonder if you could touch on -- indeed, I wonder if I should do this. Let's go to page 7 of Dr. Kent's report, please. And you'll see that there's reference to what's titled "The Putative Novel Virus" which describes Dr. Kristi Miller's, who's going to be testifying later this week and her work with respect to what I take to be termed the mortality-related signature.

Dr. Kent, I wonder if, as I say to you, to preface this we'll be hearing from her and learning much more about her work. Could you comment from your point of view as you go through

this subjective risk analysis for Fraser River sockeye for a host of different pathogens or diseases, where does Dr. Miller's work on this mortality-related signature fit in or does it fit in?

DR. KENT: Well, it doesn't really fit in because my directive was looking at infectious agents and this is a host response. I think I -- a simple analogy would be if you found a -- you're looking at a certain lesion or change, I know that there's -- looking at recent documents they're starting to get some evidence of a parvovirus as associated with this infection, but at the time that I prepared this document it was very -- it really didn't pertain because this is looking at a pathological change, if you will.

Now we used to do pathology more by looking at histological changes in the organs, but now we have these molecular methods and this would be, in my opinion, somewhat equivocal to that of Dr. Miller-Saunders and her colleagues are equating a certain type of pattern and gene expression that has been known in the literature to be associated with a virus disease. So this is indirect evidence. It's not really direct evidence of a pathogen based on the data that I was able to review and so it really kind of fits outside of the box and that's why I put this as unknown.

Q Dr. Johnson, from your point of view, do you have a perspective on -- or view on where this research fits in with other research?

DR. JOHNSON: Well, Dr. Miller's research, the Fish Health Group has been providing samples for her research from 2010 and 2011 survey work. I'm not going to speak to Kristi -- Dr. Miller's research, mostly because I'm only familiar with it as what's been presented to us at staff meetings and that so I'm not intimately familiar with what her laboratory group has been doing.

Q Number 14 on our list of documents, Dr. MacWilliams, I'd like to ask you about this, please. I won't spend time going through this document but I take it this is a document that you authored, Dr. MacWilliams, that really addresses Dr. Miller's work on this mortality-related signature; is that correct?

DR. MacWILLIAMS: Yes, it is.

Q Do you know when it dates to, either specifically or generally?
DR. MacWILLIAMS: It was early in 2009 and it was the first that I'd seen anything of Dr. Miller's work and it was a research summary that was in response to the Fraser River sockeye declines.
Q Was this document provided to Dr. Miller? Or did you provide it to Dr. Miller?
DR. MacWILLIAMS: I don't know. I forwarded it to Mark Saunders and I don't know if she has seen it or not.
Q And what was the purpose of this document?
DR. MacWILLIAMS: I was just from my perspective as a veterinarian asked -- pointing out areas where some of the interpretations being made and the assumptions being made were perhaps speculative or perhaps -- I thought some of the interpretations were over-reached and that just some more caution in experimental design should have been done.
MR. MARTLAND: I'll ask this be marked, please, Mr. Registrar, as the next exhibit.
THE REGISTRAR: Exhibit 1458.

EXHIBIT 1458: MacWilliams, Update on Science Review 2009

MR. MARTLAND:
Q On the topic of sea lice, Dr. Kent, in your report where does sea lice fit in? Was it something that you looked at or didn't?
DR. KENT: I did look at it some. I saw from the reviews of my document -- of this report that I prepared that others -- some people wanted me to expand on that a lot -- much more. There's a lot of papers out there. It's a very controversial issue as far as the impact of sockeye -- of sea lice on wild salmonids in B.C. and particularly pink salmon.
I put this as a lower priority. The main reason, you know, subsolidate it, when you say we're doing this subjectively and deciding which disease we're going to emphasize and not, I could have filled this whole report based on the time and allocation that I was given just on the discussion of sea lice.
Some work that's been done at DFO demonstrated that the sea lice are most damaging

to fish smaller -- for smaller fish and the sockeye go out in the ocean at somewhat - maybe my colleagues can correct me on that - I think somewhere around eight or ten grams, at a size when they would be much more resistant to the damage of sea lice. Sea lice have occurred on salmonids for a long time and based mainly on that knowledge and review of the literature, I put this -- and the limitations of time that I had to prepare this report, I put this as a lower priority than some people might have. If you're just going to -- if you were going to review the -- conduct a report based on the number of citations, the sea lice would have been much higher, but as I said, for the reasons I just gave you there is that the sockeye are larger when they enter the sea water. They're only going to be infected in sea water and therefore I gave less emphasis to the sea lice than some others.

Also, I know that there's going to be four other -- three or four other reports on the interactions of salmon farming with the potential demise of wild sockeye and I know that that issue -- the issue of sea lice and it's relationship to sockeye salmon will also be addressed in those reports.

Q And on that note, I'll just confirm indeed we do have a number of other reports and indeed, the panel specifically on sea lice that will be coming within the next few weeks.

Dr. Stephen, I haven't taken you to your report in any great detail. With the time limitations, I don't plan to do this in great detail. You've commented a little bit about the report and the work that you've done. I wonder if I could look to ask about your report but in the course of doing so engage both you and Dr. MacWilliams with respect to the operation and oversight of hatcheries and salmon enhancement facilities. I suppose salmon enhancement facilities is the safest, broadest term; is that...?

DR. STEPHEN: I think that would work for today, yes.

Q All right. First with respect to your findings, I'd like to read out from page 4 of your report, this is within the executive summary of your report --

MR. LUNN: Sorry, Mr. Martland...?
MR. MARTLAND: I'm sorry. This is from Dr. Stephen's report and it's Exhibit 1454.
MR. LUNN: Thank you.
MR. MARTLAND:
Q If you look in the middle of the page at the paragraph that begins:

> We could not determine...

It reads:

> We could not determine if diseases present in salmon enhancement facilities (hatcheries or spawning channels) present potential for serious or irreversible harms to Fraser River sockeye salmon. Limitations in scientific understanding, lack of ongoing surveillance of wild and cultured fishes, and deficits in data provided to us --

I'll pause to say this is in the context of the disclosure -- an application and disclosure of information to the commission from salmon enhancement -- from federal and provincial SEPs in the province.

> -- deficits in the data provided were the primary reasons for our inability to make specific cause-effect conclusions and to qualitatively or quantitatively assess risk.

Is that really the key finding that you make is effectively a conclusion that we can't say?
DR. STEPHEN: I think that's the most important conclusion of the report, yes.
Q And you describe in your report the method you use, but I take it that conclusion we can't say is true both with respect to what the literature says but secondly, as I alluded to with respect to what the data that were provided say to you?
DR. STEPHEN: Yes, we took two approaches of trying to look at the literature and then look at the facilities' specific data and we had the same challenges in both approaches.
Q At page 2 if we flip back two pages, and we just go down to really the next part there's a

paragraph beginning:

> We know of no...

And I'll read it out:

> We know of no legal fish health standard that establishes an acceptable level of fish pathogen risk for enhancement operations except for legislation dealing with the exclusion of foreign or exotic disease from Canada. A single standard for acceptable exposure cannot currently be defined as the capacity for individuals and populations to cope with a disease is context specific and would be affected by things such as the pathogen, host species, life stage, habitat quality, water temperature and many other factors.

You go on to write:

> A health standard of no infectious or parasitic micro-organisms or diseases in Fraser River sockeye salmon is unattainable because; infection and disease are normal in wild fish populations and a variety of infectious agents are ubiquitous in aquatic environments or common in cultivated or wild fishes.

Could you comment on those points that you make, please?

DR. STEPHEN: I think that the importance of that is again, when I outline what we do for risk assessment, the first star for me is to understand what risk target we're going for. A lot of disease in the past - and animal health has been zero or some - and if we think of foot and mouth disease, one case of foot and mouth disease in Canada would be unacceptable. So a lot of our legislation on animal diseases have been based on trade and barriers to trade. Finding one animal would be enough to have a barrier to trade. But when we look at some of these other diseases, there's obviously ecological considerations, economic considerations and social considerations

as well and if we can't have a zero or present perspective for managing a population, we need to think about what would be reasonable when we look at the risk to say have we met that threshold of acceptability.

Again, and I was a little bit shy in putting in we know of no legal standard because we certainly aren't lawyers by any means, but when we look at the legislation for this and other projects, I think things like, you know, the ***International Boundary Waters Act*** or some of those sort of things talk about prevention and movement of pathogens, but nobody says it's okay to have one percent or five percent or two percent, and so we have no management standard against which to work. And because, as you've heard from the other panellists say today, pathogens and diseases are part of normal systems. We really can't have a zero.

So this is the very first challenge we had when trying to assess the risk and if there was an acceptable risk by saying what external standard can we use for acceptability.

Q In terms of the -- I wonder if I can just use a metaphor and tell me if it works. When we think about the impact on wild salmon I think you're saying two different things. First of all, we don't have -- my analogy, I suppose, to carpentry. We don't have the things that we want to measure, but more than that, the measuring tape is not standardized. I may be able to -- you were talking about not having a standard against which to assess or understand risk. Is that that sort of a complaint, as well?

DR. STEPHEN: Well, let me just clarify. It's not that we don't have a standard. There's multiple standards with different perspectives, so -- and I don't want to suggest which would be more correct at this point. But there are definitely different measuring tapes out there and as you've heard earlier, especially if you want to measure health and well-being of salmon, going out and counting pathogens is insufficient to really measure that and that's been the focus of most of the fish health work. So this is why we've got this deficit of knowing where to measure and the tools to measure and then having a variable measurement

tape, to use your analogy.
Q What did you conclude with respect to the screening for disease at enhancement facilities?
DR. STEPHEN: I think that we can see at enhancement facilities, there's a number of ways they look for diseases. One is in response to problems which I think is a significant part of their work, where the hatchery managers might recognize there's a problem that they might need investigation or medication or support from their veterinarian. There's other times when they have some programs to specifically look at some pathogens such as you heard earlier bacterial kidney disease. There are some screening done on brood stock where they will catch things other than just those diseases and if we talk about the provincial hatcheries, as well as the federal ones in that case, they will look at some pathogens.

I could not find evidence of systematic ongoing population surveillance so all individuals are sampled in a random, systematic way, so it tends to have -- focus on particular conditions and in not all cases are animals tested for all possible pathogens, which is a very reasonable approach for utilization of resources.
Q Dr. MacWilliams, do you have comments of the sufficiency of the current level and approach to disease screening for federally overseen enhancement facilities?
DR. MacWILLIAMS: Sorry? Could you ask that again?
Q Do you have a view on the sufficiency of disease screening at enhancement facilities? Is the disease screening that goes on now all that it could or should be?
DR. MacWILLIAMS: We are -- the level of screening is, in my opinion, it is sufficient. We do probably not miss any disease outbreaks. We screen for bacterial kidney disease in watersheds that we know the pathogen is present at a higher level than normal and we are -- do also have a range of management steps to intercede and try to mitigate against so we can work toward lowering it -- lowering that disease within those watersheds. We have similar programs in place for IHN virus in sockeye stocks where we are doing annual screening of the brood stock and also have a number of management practices in place to specifically

address that pathogen, virus-free water source, compartmentalization of sockeye only to those sites, or -- and if multiple sites, compartmentalization between those stocks. So we do have a number of processes in place for management of the diseases that act to limit the number of -- limit the disease risk.

We also have in the last few years done some pre-release screening at major facilities only and we're hoping to go further toward that in the future. So with our management policies in place, yes, I think that our screening and our disease efforts are sufficient.

Q In the perfect world are there things like vaccinations or prophylactic measures that could be used more rigorously or regularly across enhancement facilities?

DR. MacWILLIAMS: Definitely. I'm not saying that we couldn't do better. We absolutely could. Specifically speaking to vaccinations, we are very limited in that the majority of our fish, the pinks, chum and sockeye, which are the vast majority of fish that we release, are normally leaving our facilities in a .2 to one-gram size. There are no effective vaccines for that size of fish. The immersion vaccines become effective after two grams in size. The injectable vaccines you can start giving them at ten grams in size but they are more efficacious if they're given later and give longer protection if they're given to fish that are more in the 20- to 30-gram size. So there are -- we are constrained by what's available in a commercial vaccine and also by the life stages and the size of fish that we release.

Q If I could bring up the top of page 3 please, Mr. Lunn, from this report. Dr. Stephen, in your report you make reference to having documented -- this is four lines down - cases where fish with known or suspected infections were released from salmonid enhancement operations into fish-bearing waters. That really gets us to a question around whether that occurs, why that would occur. It may seem to someone surprising that fish that were, for example, BKD-positive were released into the wild given, for example, what Dr. Kent has told us about the risk level from BKD for sockeye.

Could you comment - and I've got one or two

documents I can take you to or you're welcome to go to in answering. Dr. MacWilliams, could you please address that question?

DR. MacWILLIAMS: Yes, the enhancement hatcheries do periodically release fish that are known to be carrying pathogens. Specifically, bacterial kidney disease is one that we on our hot zones occasionally if the pathogen is detected during rearing, we will treat with antibiotics and we will do a pre-release screening of the population and try to determine a population level prevalence of that pathogen. And if our tests indicate that the population is too high, we will cull that population as opposed to release.

But a zero tolerance doesn't work with that pathogen in that it is endemic and we -- at any site we are taking up to 30 percent of the escapement for our rearing, and of those -- so if the pathogen is high in prevalence in a certain year, we're only taking three out of ten fish that are in the system. The other seven are naturally spawning but the fish that we take in we are disinfecting the eggs, we are taking the results of our screening and managing with our egg segregation culling program the female that test high positive. Their eggs are removed from the facilities and destroyed. And we also provide optimal nutrition, do predator control, so we're trying to give them the best chance they have. If we still see a disease outbreak in our yearling production of bacterial kidney disease then we can manage through therapeutants and also we do risk assessment prior to release. But having a zero tolerance and saying we're not going to release any is not possible.

Other instances where we may release fish with disease would be after parasites, costeotrichina (phonetic), that are normal skin or gill parasites that are also endemic pathogens, ubiquitous in wild circumstance and we release them with some -- some assurance that sea water is somewhat curative because it's one of the modalities used to treat them. So as they're migrating out, there is a risk that they are going to pass that horizontally to other freshwater stocks, but that that exposure will decline in the estuary and beyond.

And the only other circumstance I can think of where we may release disease-positive fish is a number of our facilities will do sea pen rearing and in the sea pens once they're in the sea pens to keep them and treat them and hold them for a period of time to ensure the treatment was effective and go down that road, it becomes somewhat questionable in terms of their -- the biological needs of the fish to actually get going. So in a sea pen circumstance, the rule is -- rule of thumb is normally that if any sign of mortality, regardless of what the cause is, we let them go. We consider them once they're in the sea pens to already be essentially wild fish and we let them go as soon as possible to prevent any horizontal transmission between the population and -- but if we're doing that with a suspicion of disease at a very low level of mortality or morbidity, we're also requesting that they get a sample to the lab so that we can confirm what they're dying of or what they're looking sick from before we release them.

Q To better understand the approach of the department and your approach on, in particular, this question of BKD ourselves, if I could look to number 10, please, Mr. Lunn, on our list of documents and this I won't take you through it, but I take it this is quite a -- from your perspective probably an articulation of the rationale for how it's indeed titled, the specific pathogen control plan for any bacterium at B.C. Federal enhancement hatcheries and affiliates. This really articulates the approach that's taken?

DR. MacWILLIAMS: It does.

MR. MARTLAND: If I might ask this be marked as the next exhibit, please?

THE REGISTRAR: Exhibit 1459.

EXHIBIT 1459: Specific Pathogen Control Plan for, at B.C. Federal Enhancement Hatcheries *R. sal* and Affiliates

MR. MARTLAND:

Q And as a shorthand number 8 on your list of documents it describes the six categories of results from the ELISA or ELISA test for BKD or *R. sal* and I won't have you explain that, but that is

the test that's used for BKD?
DR. MacWILLIAMS: For screening of the adult brood, yes.
Q Okay. And this is a document number 8 on our list of documents that dates the September 29, 2010 from you to a manager -- I'm sorry, just at least John Willis recipient.
DR. MacWILLIAMS: He is the manager at Snootli Creek hatchery.
MR. MARTLAND: If I could ask this be marked as the next exhibit, please?
THE REGISTRAR: 1460.

EXHIBIT 1460: Memo from C. Williams to J. Willis et al re Broodstock Screening results - Lakelse Sockeye dated September 29, 2010

MR. MARTLAND:
Q And I take from the description here that it's not simply a "yes" or a "no" test.
DR. MacWILLIAMS: No. No, the levels of the pathogen within the brood stock follow a continuum from negative to very high levels and we put in the categories you can see there of negatives or low level of detection. Those fish are considered suitable for yearling rearing programs. The low positives we consider those to be suitable for fry release and so they won't be held for a year at the facility, and the moderate positives and high positives are ordinarily destroyed. The high positives, the cut-off of greater than .06, should note that, you know, the highest value we've seen in our ELISAs is an OD value of greater than three. So we're still on the conservative end and I believe that we are -- we manage this pathogen and disease comparable to how it's managed in all Pacific Northwest hatcheries of our neighbouring states, as well.
Q And I wonder, Dr. Stephen, do you have comments on whether you see a risk remaining or a risk arising from a practice that -- or an approach that permits the release of fish as you've just heard described?
DR. STEPHEN: Well, I mean, I'll take you back to the earlier question about the most important conclusion, which was the inability to actually determine what risk is because of the challenges

of understanding if an exposure occurs. And so to sort of speculate on this particular disease and this situation is challenging. Certainly as you heard earlier, this idea of additional stressors being added to populations is never desirable, whether it's a pollutant or a pathogen or a habitat change, but with the information available you can't specify if this truly increases risk against background levels due to the inability to see if these fish truly interact in transmission to each other.

Q I'm noting the time and I'll need to speed along to a conclusion, so I'll look to now move to number 12 of our list of documents. Dr. Johnson, I'll perhaps direct this question in the hopes that you may have looked at or have some familiarity with it. It bears a date stamp of July 5, 2011. Indeed, I'm just told that it is already an exhibit, which I hadn't made a note of so I'll find that exhibit number in a moment. This document is given to the deputy minister with respect to providing information about work that's been done to understand what happened for Fraser sockeye in 2009 and perhaps more generally with the decline over time.

What I'm most interested in - and it's Exhibit number, we think 1364 - we'll pick up on that and confirm in a moment.

I'd like to go to page 3 of the memo, which may be page 4 of the PDF document. There's four -- you'll see in this passage that there's four factors that are classed as being most likely that led to sockeye mortality at the scale observed in 2009: low food abundance in the Strait of Georgia; low food abundance in the Queen Charlotte Sound and Gulf of Alaska -- skipping to number 4, toxic algal blooms in the Strait of Georgia and then back to number 3, disease.

With respect to the disease description that's given there, doing this awkwardly, but before I forget to do it, it's Exhibit 1371 is the correct exhibit number. This is already an exhibit. With respect to the advice that's given there on disease, do you have any concerns or comments on that advice?

DR. JOHNSON: I think that this whole issue of the role of pathogens may have played in the decline is all

related to the other three factors which are listed here. So what the document is essentially saying is that we know that there are many disease -- many pathogens present in sockeye salmon and we know that factors such as low food abundance, possibly toxic algae blooms can affect how these pathogens would impact sockeye salmon, so that's why I think disease has stayed in there. There's also, of course, the interesting work that Dr. Miller's done with her genomic signatures which suggest that a fairly large number of the fish showed this signature. But it also does note that the actual pathogen responsible for that signature hasn't been determined.

And on an earlier statement I should correct that we are doing some other work with Dr. Miller. Dr. Garver is now working with Dr. Miller on doing some parvovirus challenge work with sockeye salmon so I'm sorry, I forgot to mention that.

Q With respect to the work that the DFO is involved in now and indeed that you're intimately familiar with, Dr. Johnson, we understand that that includes a research program to examine the health of Fraser sockeye in the Strait of Georgia and that although that work is ongoing to date, it has not revealed that there's been, I gather, histology testing - and my note was 250 fish at this point. That may have changed. I don't know if it's a moving target. Could you comment though as to the state of that work and what results, if any, you have to this point?

DR. JOHNSON: Okay. In 2010 it was -- well, we basically came up with a program to approach sockeye salmon health more from an overall health perspective rather than simply doing more surveys for disease. So the goal of this program is to integrate with our fisheries biologists, fisheries ecologists, the disease staff, Dr. Miller's group, to come up with an overall assessment of health status of Fraser River sockeye starting in the lake, throughout their period of migration through the Strait of Georgia. So we received three years of funding. The first field season was in 2010 and that year we also received some support for marine harvest for some of the ship time, and some work from the salmon foundation, Dr. Riddell's group.

So in each of these years, we have done large-scale surveys of sockeye salmon throughout the Strait of Georgia at up to 70 to 80 different sites ranging from the mouth of the Fraser River right to through Johnstone Strait. We've also collected fish in 2010 at the mouth of Chilko Lake where we take advantage of the fact that there's a counting fence that we can actually obtain samples. And this year in 2011 we also added sampling of fish in the lower river, just immediately before they leave the strait.

And on these fish they're receiving a complete health assessment. 2011 we've included things such as water chemistry -- well, 2010 have water chemistry, but in 2011 we've also done toxic phytoplankton sampling with associated surveys, so I'm seeing this as a real sort of change away from just sort of everybody doing their own thing and trying to bring everybody's expertise. Like we've sort of -- Kyle -- Dr. Garver is doing the virology work and we're using recognized and validated diagnostic tests, as well as a lot of histopathology and all of the results of the 2010 survey were presented in this -- at this workshop, which was the April 14th workshop that DFO hosted for the staff. I don't know what else...

MR. MARTLAND: So I appreciate that answer. Mr. Commissioner, I dare not run long and then be telling my colleagues to conclude on time, so I'm going to conclude my questions there. I have a note that Canada, Mr. Taylor, has 80, eight-zero, minutes.

MR. TAYLOR: Thank you. So by my count then I have 20 minutes now and then 40 minutes after lunch. Sorry, 60 minutes after lunch.

CROSS-EXAMINATION BY MR. TAYLOR:

Q I'm going to start and do similar to what Mr. Martland did, that is, to ask questions about technical paper 1 and then move from there to technical paper 1A and my questions on report 1 will primarily but not exclusively be of Dr. Kent and Dr. Johnson and 1A of Dr. Stephen and Dr. MacWilliams. But please, panellists, if you have something to say in answer to a question, even if I haven't specifically directed to you, I'd be

most pleased to hear from you.

My first question is going to be general of Dr. Kent and Dr. Stephen and I'll take each of you in turn. Dr. Kent, how long were you given to do the work that then resulted in your delivery of your paper to the commission, approximately?

DR. KENT: Oh, I would say approximately six months, as far as the timeframe, as far as the amount of hours devoted to it, is that right?

Q Well, I suppose hours are important --

DR. KENT: Yes.

Q -- over a course of time but it's the timeframe that I was mainly interested in. Just in terms of hours, we don't need to account for your hours, as such, but were there other things in your work life that were impinging during the six-month timeframe that would have prevented you getting at this in any significant way?

DR. KENT: Well, I'm a full-time faculty member at Oregon State University and my research and teaching responsibilities there so I worked mainly in the evenings and weekends on this particular project.

Q All right.

DR. KENT: And we can go back and calculate that basically I would say it was somewhere around 24 days of -- 24 eight-hour days, my guess, is --

Q That's fine.

DR. KENT: -- about that.

Q Like many academics, I take it then that this was an extra piece of work beyond your regular university teaching and as you just said, so you spend your evenings and weekends doing this for this particular commission.

DR. KENT: That's correct.

Q And did the timeline that you were working under contribute to and limit in any way the amount of data that you were able to bring in and, in turn, assess and analyze for this work?

DR. KENT: I don't think so. I was given a large amount of documents, grey literature documents, pathology reports from -- through the commission from DFO and I felt that I had adequate time to assess them. I reviewed a lot of these documents. I don't feel that my report was compromised by the amount of time that I was given. It's not like there -- in other words, I don't believe that

there's a big body of literature, large body of literature out there that I just didn't have the chance to review that would have been pertinent and changed my overall conclusions on the report.

Q All right. Thank you. And in addition to data and information that you got from DFO did you get some from the Province of B.C. as well through the commission?

DR. KENT: I believe so.

Q So in sum then, you feel you had quite a good collection of data as to what's available and you had the time to assess it?

DR. KENT: The only compromise in my time would be that at the very -- a number of documents came in -- I teach a course back in Maine ever summer and I was teaching it last week and I actually made sure that we didn't have a conflict with this. And a number of documents came in just a few days ago that I haven't had an opportunity to review those.

Q All right. Dr. Stephen, I have the same questions of you for your quick answer to that. How long were you given to do the work that then resulted in the delivery of your report to the commission?

DR. STEPHEN: I'm thinking of February to middle of July. That allowed us a start on the literature review right away but there were more delays in getting some of the hatchery-specific data and, most importantly, it came in about 3500 PDF files rather than a database, so we had to spend a lot of our time just re-entering and cleaning the data. So it did cause some time crunches, without a doubt, and didn't allow us to go to local facilities and validate things or ask follow-up questions that we might have liked in a more timely and thorough examination.

Q All right. And with that are you saying that there's some gaps in what you were able to take in and analyze?

DR. STEPHEN: Well, like Dr. Kent, I think that we got the literature covered off quite well. I think that to me when I look at -- when I go and do field data, I always like to go and talk to the people who generate those data, make sure that they've understood our request that we've got all the information that we need, so I can give a level of confidence that I've actually seen everything and I didn't have a chance to do that,

so the answer to your question is I can't tell you if there are gaps or not.

Q All right. Thank you. Now, my next few questions are of any and all panel members so jump in as you see fit. And they have to do with all species using the Fraser River system. They're all using the same water, of course, and you've spoken some of this, something of this, various of you, and we may have some more, but there's pathogens in the water, both fresh and ocean, at all times and quite a number, as I understand it. And we have some species that seem to be doing quite well and other species not doing so well and there's some decline in the sockeye stocks which, of course, is what led to and what this commission is about. But pinks, for example, are doing quite well and there are some other species, as well.

So any of you have a comment or explanation as to why it is using the same water with the various pathogens that all of the fish would be going through and/or living with, why some species are doing better than others? Does anyone want to take that on?

DR. KENT: If I can speak in generalities, the fish have different -- we're talking about -- let's say -- I assume you're talking like different species of salmon; is that correct?

Q Well, no, not only salmon but other fish too.

DR. KENT: Okay.

Q But mainly salmon, I would think.

DR. KENT: One explanation for a difference as it relates to pathogen is we see dramatic differences in host susceptibility and susceptibility based on the species of salmon. That's one explanation. And a second explanation - this is just some very general - they have different -- the fish have different life histories. Pink salmon go out in the ocean immediately. Sockeye salmon are going to spend the first year or whatever in fresh water. So they have very different life histories and very different susceptibilities to different pathogens. So you can't -- a sockeye salmon is very different than a pink salmon in a lot of ways. That's my general comment on that.

Q And, in fact, risk is very life-stage dependent, isn't it?

DR. KENT: Yes.

Q And so - and we'll come to the other panel members in a few moments, but continuing with Dr. Kent, so in humans, you can sometimes think of the very young and the very old as being particularly susceptible to even such things as the common 'flu that those of us who are in between young and old may not be so much vulnerable to; is the same true of fish?

DR. KENT: Yes, the same is true. There would be certain vulnerable life stages. One is fry, as Dr. MacWilliams pointed out that the very little, very young fish, you can't vaccinate them because they don't have a competent immune system. So one very critical stage would be the very young fish. Second very critical stage is during smoltification. There's a high energy demand and often fish are more vulnerable to diseases when they're going from fresh water to sea water, and also during that stage you're seeing a whole suite of new pathogens that they've never encountered in their life. They've spent their life in fresh water and they have developed immunities, certain freshwater pathogens, et cetera, and now they're in the sea water and seeing a whole suite of new pathogens. So that's a vulnerable stage.

The third very vulnerable stage would be in returning fish. Pacific salmon species are destined to die when they return to fresh water to spawn, except for steelhead, steelhead trout, they can survive multiple years. So when a returning salmon comes back to fresh water, again it's seeing a new -- they've been in the marine environment for one, two or three years depending on what species they are and now they're coming back into fresh water and again seeing a whole bunch of -- a whole suite of pathogens that they haven't seen for a long time, if you will, in their life. And more importantly, and probably the biggest driving factor is that their immune system, they stop feeding and their immune system becomes severely compromised when they come back as adults.

So expanding, you know, that's basically the three phases that fish are -- that salmonid fish are -- where they're much more susceptible to infectious diseases.

Q All right. Thank you. Other panel members, do

you have a comment on explaining why or how some species - and we can largely address salmon, pinks for one, why some are doing so well and others not, even though they're all living with the same pathogens? Resistance, of course, is one thing. Dr. Johnson, do you have anything to say on this?

DR. JOHNSON: Yes. I think I'll add a little to what Mike said. I think that we should look at the fact that there are pink salmon doing quite well in the Fraser River and work towards developing a better understanding of how they relate to pathogens in comparison to sockeye salmon, for pathogens such as sea lice, for example. And I think that we could probably learn a little from that.

But I do agree with Mike, is that we need to assume that there are differences in their susceptibility to pathogens and there may be differences due to the different sort of life history stage they're at when they enter sea water. But I think that it would be very interesting, and I'm not sure of the exact relationship between sockeye and pink salmon with respect to, say, BKD. I know that BKD can be quite common but which is more susceptible, sockeye or pink, I don't know that. But I think that information could be -- some of that information could be found and it might be very interesting to consider when you're talking about the role of diseases in sockeye salmon.

Q Dr. Stephen, did you want to add to this?

DR. STEPHEN: I think I can just reinforce it. It's the same -- you've asked the difference between species. I think you just have to look outside our windows here and look at the difference between the same species of people and different life histories, different challenges, different patterns depending on where you live, your socioeconomic status. Similar things happen in animals, so even within one group of sockeye salmon, depending on where they reside in the lake, I think there was some work done by Leo Margolis years ago where if you caught Kokanee at one depth versus another depth, they'd have a different parasite suite because they're looking at different parts of the food chain.

Now add on the fact you have different

species, I don't think you can assume that their ecologies are the same, so their timing of their exposures, their susceptibilities and their capacity to handle those would be the same. And now when we go out to other species, whether it's sturgeon or river otter, that complexity gets even more abundant.

Q All right. Thank you. Dr. MacWilliams, do you have anything you want to add?

DR. MacWILLIAMS: The only thing I can think to add would be that not only life stage but the life stage and the life history when they leave fresh water, all those timing issues are going to also depend on how much pathogen exposure they're going to come in contact with. So it is very complex and whether or not they have concurrent infections or whether or not they have any adequate nutritional play and all questions of the host immunity with the environmental questions of -- and the pathogen questions, those very complex interactions taking place.

Q All right. I wonder if we might turn to Canada's document Tab 3, which is a PowerPoint presentation. Thank you. Dr. Johnson, this is something you prepared, I think, isn't it?

DR. JOHNSON: Yes, this was prepared for the April workshop that was held on the factors related to potential causes of sockeye declines.

Q Okay. And I think there's been reference to that April workshop and you're speaking of April 14/15 of this year, are you?

DR. JOHNSON: Yes, I am.

Q Just very briefly, 'cause for immediate purposes that workshop isn't the focus, but can you just very briefly let the commissioner know what was that workshop so he can get this in context?

DR. JOHNSON: The workshop brought together a variety of DFO scientists who were working -- who work in the different areas which were proposed as being possible factors related to both the rather disastrous decline of sockeye salmon as well as long-term declines. It was basically an opportunity for everybody to get together and to provide an update on where they were at with respect to the research that they were doing and how they thought -- they may have changed -- whether they'd changed their opinions or not.

The piece that we're seeing here was done primarily as an introduction to allow staff members who were not knowledgeable about diseases, so it covers many of the things that we talked about today, the importance of the environment and things like that in interactions with -- between hosts and pathogens. It also provides us with a bit of an overview of the survey work that's been done in the Strait of Georgia.

MR. TAYLOR: All right. Could this be marked as the next exhibit, please?

THE REGISTRAR: Exhibit 1461.

EXHIBIT 1461: PowerPoint presentation - Introduction to Pathogens, Diseases and Host Pathogen Interactions of Sockeye Salmon

MR. TAYLOR:

Q If you turn to page 2 - and this is a question for all of the panel and I'll give you a moment to look at that, but there's a statement that Dr. Johnson has set out in his deck here and presented, as you've heard, in April, that covers some of what we have heard from you over the course of the morning in a compendious form. I think you can ignore the handwriting on that particular page. I don't quite know what it means, but for present purposes, just leave it -- put it to one side.

Do each of the panel members agree with what's set out there? And Dr. Johnson, we'll just take it that you do agree, of course, because you wrote it, but do the other panel members agree that that's a good compendium of pathogens and their existence and relationship to disease and that being multi-factoral?

DR. JOHNSON: I would agree. Maybe I'd add a little bit on item 2 is:

Pathogens have co-evolved with their hosts.

That's assuming that they're not exotic pathogens that the host has never encountered in their -- previously.

Q Yes, thank you. That's a good point. And the pathogens you were looking at are endemic to B.C., aren't they?

DR. KENT: Yes. They're -- all the pathogens I've looked at are endemic to B.C., from my review of the literature, et cetera, to conversations I've -- there's no indication that I have that there is an introduced pathogen involved with this scenario.
Q All right. Thank you. Dr. Johnson, it looks like you have something to add.
DR. JOHNSON: Yes. And this presentation was only on the endemic pathogens.
Q Right. Thank you. Dr. Stephen, Dr. MacWilliams, is this a good account for what it's covering there?
DR. STEPHEN: Yeah, I think it's a very general model for how disease is multi-factoral. And to add to the point too, I guess my only other caution there is to make sure we don't always assume that co-evolution means they come to benign co-existence, because that's not always the case.
Q Okay. Thank you. Dr. MacWilliams?
DR. MacWILLIAMS: I think it's a reasonable generalized model, absolutely.
Q Then if you look at page 4, it speaks to challenges to quantifying disease impacts and Dr. Kent, in particular, you spoke to that before. And I've got two questions of the panel. One is probably relatively easy to answer and the other might take a bit longer.
The first question is whether this is a good compendium of the challenges that exist and the second question has to do with concurrent infections which you'll see in the final bullet. But taking them one at a time, is this a good compendium to the challenges? Dr. Kent, you spoke of this before, so if you have anything to add, by all means; otherwise, we've got your evidence from before.
DR. KENT: This is the first time I've seen this, so I'm just reading this through right now.
Q All right.
DR. KENT: Yes, I agree with all those statements.
Q Okay. And Dr. MacWilliams?
DR. MacWILLIAMS: I agree with the statements, however, I think it's also missing -- I'm assuming this is referring to disease impacts in wild populations and I don't think that this discusses the difficulties in the sampling wild populations and

getting random samples or in getting sufficient numbers. Yeah, I just think it's missing the difficulties of actually surveilling wild populations.

Q All right. Dr. Stephen, is this a good compendium, perhaps with the addition that Dr. MacWilliams has just put in?

DR. STEPHEN: I think I can agree that these are all definitely challenges for infectious disease research. We make clear they're talking about infectious diseases and I agree with Dr. MacWilliams of the other challenges, as well.

Q Now, in terms of concurrent infections, and you wrote this, Dr. Johnson, so I'll ask the question and then I guess it might be appropriate if we break for lunch and you can think about -- all of you can think about the question over lunch. But with the reference there to concurrent infections, and bearing in mind that one or more of you spoke earlier about the studies that have been done so far generally involve single pathogens, concurrent infections is both a reality and adds a huge complexity to this whole equation in terms of trying to find out what impact a given pathogen might or what contributing impact a given pathogen might or might not have, doesn't it?

MR. TAYLOR: So I'll leave that question and if it's agreeable, Mr. Commissioner, we can stop now for lunch and come back.

THE COMMISSIONER: Thank you, Mr. Taylor.

THE REGISTRAR: Hearing will now adjourn till 2:00 p.m.

(PROCEEDINGS ADJOURNED FOR NOON RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: Hearing is now resumed.

CROSS-EXAMINATION BY MR. TAYLOR, continuing:

Q Thank you. Before lunch I left the panel with a question that essentially had to do with their being studies so far or most of the studies being on single pathogens, one or more of you have spoken of concurrent infections and I suggested in a question that that adds a huge complexity to trying to isolate the contributing factor that might be associated with any given pathogens and I

left that question with the panel to consider, so now is your opportunity. Who wants to start?
DR. KENT: There are a handful of studies with salmonids on co-infections and their interactions. I can just think of a couple that come to mind from my geographic area in Oregon. As I mentioned in one of my earlier statements about a parasite that's very common and somewhat pathogenic to salmon called *Nanophyetus*. It's a worm. Some work done by NOAA fisheries showed that fish that were infected with this worm were more susceptible to the vibriosis. That's one example that I could think of. And recently I had a student that just completed his Ph.D. and his papers are in press or have been published on multiple -- the interactions of multiple parasite infections in coho salmon. So that's -- I'm sure that's biased towards my geographic area and my lab, but those are a couple of examples that I can cite.
Q What I'm really thinking of and getting at here is that in order -- when you have co-infections or concurrent infections, rather, in order to understand what is the contributing factors, if any, of a given pathogen it's usually complex because of the inter-related concurrent nature of the infections that are at play; is that right?
DR. KENT: That's correct. I totally agree.
Q And do the other panel members all agree with that?
DR. JOHNSON: I agree with that statement.
Q Listening to the evidence -- I'll take the lack of anyone else saying anything as agreement unless you speak up and that's fine.
DR. STEPHEN: Well, I'll speak up then.
Q All right. You speak up.
DR. STEPHEN: Well, I think -- I mean, your attempt to characterize complexity is simplistic.
Q All right.
DR. STEPHEN: These are hugely complex on some levels when you're getting down to mechanisms, and we're only talking about the interaction with pathogens and pathogens. You're not looking at interactions of pathogens with pollutants, for example. Some work was done in Oregon, I believe, years ago looking at the impacts of pollutants on susceptibility to pathogens. And the question of complexity comes back to describing individual

mechanisms of disease versus population impacts. So I absolutely agree these are complex systems and I just wanted to make the addition that it's to our detriment if we only think about pathogens in these sorts of equations.

Q Okay. Dr. MacWilliams, you're nodding or indicating you have something to add?

DR. MacWILLIAMS: Just agreeing.

Q All right. You agree with -- okay. Thank you. Listening to the evidence that's gone on so far today, as I hear it and the take-away I get from it and from the papers that we've seen is this. There are pathogens. Some are identified as high-risk, but at the same time we rarely see outbreaks of disease in captive fish, whether they be farms or enhanced, and therefore, a take-away that one can have is that pathogens while they exist and can cause disease, can also be successfully managed and are, in fact, being successfully managed. So I put that out and ask the panel if they can speak to that point as to disagreeing or elaborating on it.

Dr. Stephen?

DR. STEPHEN: I was just going to ask us for you to clarify what your marker of success is. When you define these are successful, how are you defining that?

Q Well, it's nothing magic but simply that you don't see catastrophic events occurring hardly ever. Does that help?

DR. STEPHEN: It does help and I guess that's an important distinction because as you heard with Dr. Kent earlier, there's many things other than catastrophic effects that pathogens can do.

Q Mm-hmm.

DR. STEPHEN: And in a lot of wildlife disease literature, the non-catastrophic are probably those that have the more population regulating effect. You know, that and fewer eggs produced per female, that less energy they get up the dam, so I think that's -- so I wanted to see if you're talking just about catastrophic or the full suite of potential pathogen effects?

Q Well, catastrophic may be too strong, but a result that is seen as a problem, a big problem. The long and the short of what I'm putting to you is that while there are pathogens and there can be

disease, that pathogens could be managed. That's the point.

DR. MacWILLIAMS: I'd like to describe the biosecurity measures that are used for enhancement fish.

Q All right.

DR. MacWILLIAMS: In captivity. And so the principles of biosecurity, there's three main tenets and one is that you want to keep pathogens out of your facility, one is if they do happen to get in, then you want to prevent them from spreading, and the third is the efforts that you do to keep your population as healthy as possible and reduce their susceptibility to the pathogens having a deleterious effect.

So to keep pathogens out in the enhancement facilities, we will choose our brood stock for the sites that do BKD management, they go beyond this, which you'll note from other documentation, but every fish, every brood fish that is looked at is examined. If the female looks reasonably healthy, she'll -- they'll collect eggs from her. If the eggs look unusual or if the ovarian fluid is bloody or cloudy, those eggs would be discarded. So the initial surveillance comes right at the start for every brood fish.

And brood fish for enhancement hatcheries, we do use wild returning brood fish. They're probably the biggest risk to our facilities because they do carry a certain pathogen load that's higher than normal circumstance. Beyond that we also do egg disinfection, we'll do egg fungus prophylactic treatments for the sites that have egg fungus issues, depending on their water quality. We'll do -- use well water or pathogen-free water for incubation for the most vulnerable life stages.

In preventing disease from spreading, we do daily surveillance. Those fish are looked at and fed every day. If there's an issue, it's often detected. Usually the first sign you'll see that something is going on in the population in terms of illness is that the feeding response is lowered and if the feeding response is lowered, the fish aren't breaking surface in response to feed, then the fish culturists are experienced. They're not casual observers. They're experienced enough to know that's a problem and they increase how

they're looking at the fish.

Any sick fish on the edge of the population or are going back against the screen, not able to hold their position in flowing water, are culled. The on-site people do examinations of those culled fish and we have thresholds in place that if the mortality or morbidity rate reaches a certain threshold, they are expected to contact the fish health professionals. And there is a hierarchy that they contact. Fish culturists will go to their manager, go to their community advisor, go to their support biologist, contact me or the fish health technicians at the biological station directly.

So there is a response in place. And we also will practice separation of stocks so our brood stock holding will be separate from our incubation with foot baths and disinfection stations in between. Separate classes, separate species will all have specific areas. Unfortunately, we aren't able to have dedicated staff for each unit. The same people do the husbandry and care for all levels of animals on facility; however, their traffic flow patterns will be designed or determined to follow the course from the most susceptible populations. You work in incubation first and go to your general population. If you have diseased animals, known diseased animals, you'll do those at the end of the day or your brood stock at the end of the day. So there's traffic flow patterns so that you're not -- I'm unlikely to spread disease from one marine container to another.

They also have disinfection measures in place where they use the known disinfectants at the appropriate concentrations for any materials that come in contact with fish or possibly diseased fish especially. And those are routinely applied. And for keeping fish healthy and lowering their susceptibility we optimize nutrition as best we can. We limit handling events. Our animals -- they're used ponded into the only container they're going to be reared in. It will be shortened, so instead of going into a long raceway with very small numbers of fish, they'll go into just a subsection of the same raceway and as they grow, more space will be allotted to them, so we

control our densities because low and high densities can both be stressors causing aggression among fish to try to develop hierarchies.

So there are many management practices in place to help prevent disease exposures and consequences at culture facilities.

Q All right. And in addition to that, there's you. You're the veterinarian to the Salmon Enhancement Program, as I understand it. Can you just, while we're at this, briefly explain your role and your involvement or contact with the various facilities?

DR. MacWILLIAMS: Okay. Well, I work out of the Pacific Biological Station and --

Q In Nanaimo?

DR. MacWILLIAMS: Yes. And in addition -- or I indirectly supervise two fish health technicians who do the diagnostic lab work for the hatcheries and also for DFO Science. And in response to a disease investigation or a disease suspicion call, the first decision would be on whether or not it's deemed appropriate to do a site visit or else have the facility send fish directly to us. And we advise on sample size, we do diagnostic test selection based on what we expect. We also do -- run the surveillance program for bacterial kidney disease, that specific management program. We do pre-release screening on the stocks that have been identified as high risk of having disease on release. What else do we do? I provide treatment and recommendation advice.

Q All right. Now, the commissioner has heard in a previous round of evidence the breakdown, if you like, of the various facilities that exist that broadly speaking can be grouped into major facilities on the one hand and community facilities in the other and you're familiar with that, of course. The major facilities are the DFO hatcheries and spawning channels, right?

DR. MacWILLIAMS: Yes.

Q And I'll have the number slightly off but there's about 22 or so of those in B.C.?

DR. MacWILLIAMS: Correct.

Q And then you have the community facilities which are just what their name might imply, community-operated, run at a local level and generally speaking quite small?

DR. MacWILLIAMS: That is correct. Well, some of the community and some of the community economic development programs are mid-level facilities that do release large numbers of fish.
Q All right.
DR. MacWILLIAMS: But, yeah.
Q Are those ones involving First Nations?
DR. MacWILLIAMS: Some are, yes.
Q Okay. Now, the major facilities, the DFO facilities, in addition to yourself in Nanaimo, the major facilities have professionals on site, fish culturists or such you call them?
DR. MacWILLIAMS: Yes.
Q And would there be one or more at each of the major facilities?
DR. MacWILLIAMS: There would be more than one.
Q And those people are responsible for the fish health management plan and operations at the given hatchery?
DR. MacWILLIAMS: In concert with their manager and, yes.
Q And yourself?
DR. MacWILLIAMS: Yes.
Q What staff of that nature would the community facilities have, if any?
DR. MacWILLIAMS: The community facilities will all have fish culture staff, with fish culture just being the people who do the daily husbandry and care. And the community programs will also have an assigned community advisor which is a DFO staff person who also is there to provide them advice and technical support and as a liaison to myself and the enhancement support operations group out of the Regional Headquarters.
Q All right. And just almost finally on this point for the moment, are you aware of the approximate number of fry that the hatcheries in the aggregate in British Columbia put out each year?
DR. MacWILLIAMS: The last few years it's been around 300 million.
Q And as compared to the number of fry that would be generated through the natural spawning, what kind of number would that be?
DR. MacWILLIAMS: I have no idea.
Q All right. Dr. Johnson, if I could return to you for a moment. At the bottom of page 2 of Dr. Kent's report which is Exhibit 1449, Dr. Kent

refers to -- yes, thank you. At the bottom of that page, Dr. Kent divides the pathogens into two categories: those that cause acute disease and rapidly kill; and secondly, pathogens that cause chronic infections which are only heavy infections that are associated with sickness or death. That is, you only have a real problem if you've got heavy infection.

Do you see a third category?

DR. JOHNSON: Yes. I think we actually had a bit of a discussion on this earlier when we were discussing commensals, chronic and acute pathogens or opportunistic. So in Dr. Kent's report here, there really wasn't sort of the focus on the commensal -- well, that's the group that I believe is missing is the commensal or opportunistic pathogens, but that may be simply my -- a difference in definition from what Dr. Kent had.

Q Okay. If you couple that with -- that is the point about commensal and I think you're bringing into play the environmental factors there, are you?

DR. JOHNSON: Well, yes. As we discussed earlier, there are a variety of organisms within the environment that under the right environmental conditions can result in the disease situation. Normally these organisms wouldn't even be considered a pathogen, but under particular conditions they can become pathogenic and I think Dr. Kent provided a very good example from humans, which is the *Giardia* that many people carry.

Q All right. I want to pick up, Dr. Johnson, on something that was part of the evidence this morning and fairly briefly and that is the role of science in responding to the requests of fish managers. As you understand it, fish managers set priorities that then translate into science work and research that's done and fish managers have many priorities that they're looking at or reasons why they might want to have you study this or that; is that correct?

DR. JOHNSON: Yes, that's correct.

Q And with that do scientists have any ability to decide for themselves or science as a branch to decide what it's going to work on?

DR. JOHNSON: I think that both the senior managers, as well as fish managers, do listen to the Science

staff when they do propose new areas of up-and-coming importance for disease studies. And most Science staff have other projects which may or may not be funded by DFO which is usually more along the lines of things which they are personally interested in, as well. So the overall -- although the overall goal of Science is to provide science-based advice to senior management, there is lots of opportunity to work on other things and lots of opportunity to obtain funding from other groups and other agencies such as NSERC to do other projects.

Q All right. I want to turn, if I may, to Tab 4 of Canada's binder of documents. This is a paper that you and others authored, Dr. Johnson. It's up on the screen now. Are you familiar with that paper?

DR. JOHNSON: Yes, I'm familiar with this paper.

Q Now, this is about sea lice, which is not the topic for today, but it is a topic upcoming. I'm not going to ask you about sea lice as such, but I want to be sure that we have this paper before the commissioner. This was the paper done in 2007, was it, by you and --

DR. JOHNSON: Yes.

Q -- either Mr. or Dr. Wagner and Fast?

DR. JOHNSON: It's both Doctors Wagner and Fast who are post-docs, as well as Dr. Fast was a post-doc of mine and Dr. Wagner is a consultant I believe in Vancouver.

MR. TAYLOR: Okay. Could this be the next exhibit, please?

THE REGISTRAR: 1462.

EXHIBIT 1462: Paper entitled Physiology and immunology of *Lepeophtheirus salmonis* infections of salmonids - by Wagner, Fast and Johnson

MR. TAYLOR:

Q And just so that we understand what this paper is, is it a review of the literature and state of knowledge at that time at least about sea lice infections?

DR. JOHNSON: It's a review of the literature knowledge at that stage of time for this one particular species of sea louse. So there are multiple

species of sea lice in B.C. waters that can be found on salmon.

Q All right.

DR. JOHNSON: This is all on *Lepeophtheirus salmonis* or *L. salmonis*.

Q And the other main species is one that begins with "C" which I will try to --

DR. JOHNSON: *Caligus clemensi*.

Q -- pronounce. Sorry?

DR. JOHNSON: *Caligus clemensi*.

Q Thank you. And in writing this paper, did you apply your knowledge and expertise to it to give your best and full assessment of the pertinent literature to that date?

DR. JOHNSON: Yes, we did.

Q Now, you also address in the paper as I read it some cautions about how results from different studies are difficult to compare to the different methodological approaches and variable species and species-specific susceptibility to infection and if you look at the end of the right column on the first page, which is page 176 of the publication, under that heading "Limitations of Laboratory-Based Studies" and then over the page to the first text part of the left column, I think you'll see that, but you seem to be setting out there what I said, that is, you have to be careful in how you take the results from different studies; is that right?

DR. JOHNSON: Yes. The original goal of this paper was to try to review all of the literature and to try to get it so we could actually make direct comparisons. During that review, it became very obvious that there was so many differences between different studies that it is extremely difficult to make meaningful comparisons between studies. For example, some studies used infection methods that resulted in copepods being on the gills, which are not a normal place for copepods. But yet those data are often used to talk about impacts on the host.

So this sort of puts together all the things we sort of observed when we were trying to come up with an overall level of sea lice that would be detrimental to a host and all of the problems that we sort of encountered in trying to do that.

Q All right. And then it appears that in the upper

left quadrant of the page we're on -- yes, we're there now where it says "Box 1", which is when you look at the actual article a slightly different colour, I think, of background.

DR. JOHNSON: Yeah.

Q The upper left quadrant, those are some, if you like, tips that you have set out as to how people might structure a study so as to make for either less inconsistency or better compatibility study-to-study; is that right?

DR. JOHNSON: Yeah. And that's not -- you know, I think we could use this sort of list for a wide variety of pathogens, including sea lice and different species of sea lice. We've talked today about, you know, actually understanding what is normal. I think that's a huge -- what is the normal condition of the host? That's really critical to understanding any impact of any pathogen on the host.

We also need to know what we actually want to measure and the appropriateness of the types of measurements that we're doing. And we need to have a consistent and proven mechanism by which we report on, say, the numbers of pathogens present. There's a variety of ways that you can do it. But it needs to be something that you can compare. And we've also talked about that -- how in this case we talked a bit about how the age structure, just because you have a sea louse on a fish doesn't mean that it will have the same impact -- well, the different developmental stages of sea lice and the host have different levels of impact. So...

Q Okay. If we return to Dr. Kent's paper, Exhibit 1449, and page 6, he deals there with I'm going to simply say the initials, but it's three-quarters down, rather than trying to say the words of the pathogen, IPN virus. Do you have some comment on the inclusion of that virus in this paper?

DR. JOHNSON: Well, as far as I know, infectious pancreatic necrosis virus has not been reported in British Columbia, but I could stand to be corrected.

Q All right. And Dr. Kent, in the paper, refers to rarely documented. Do you know of any documentation of that in British Columbia, Dr. Kent?

DR. KENT: I'm -- I can't recall a specific document. I seem to recall that it had been isolated one time, IPN-like viruses have been isolated from rainbow trout. I don't know the specifics of that. There are a number of IPN viruses are a group of viruses and I don't know if it was -- what strain was actually found, so I can't really expand on that any more than that.
Q But it's on the strength of what you've just said that it got into this paper, which seems to be a fairly, if you like, tenuous --
DR. KENT: That's right.
Q -- tenuous basis?
DR. KENT: Right. So it's either rare or not at all. I do recall some report of it occurring in salmonids. I can't think of the specific document. So I'm just going by memory at this point.
Q All right.
DR. KENT: Maybe Dr. MacWilliams, do you know of any? This is much older literature. We're talking going back 20 or 30 years. It certainly, if it occurs, it's a very rare event.
Q All right. So would it be fair to change your paper from rarely documented to if it occurs it's very rare?
DR. KENT: I would be okay with that.
Q All right. And Dr. MacWilliams, Dr. Kent was turning to you and you, I think, shook your head, but so that the record gets your answer, what do you say about this virus and whether you have any knowledge of it in B.C.?
DR. MacWILLIAMS: I'm not aware of the detection of IPN in B.C.
Q All right. Dr. Kent's paper at page 8 deals with salmon leukemia virus and I think I understand that that goes by another name called marine anaemia; am I right or wrong on that?
DR. KENT: Yes. You're right and wrong, so --
Q Thank you.
DR. KENT: -- that's typical of the way science works. So marine anaemia was a name that was put -- one of the manifestations of this condition called plasmacytoid leukemia, like a lot of other leukemias and related diseases result in its most severe forms results in the host becoming anaemic, lacking red blood cells. And hence the fish show

pale -- some of the fish will show pale gills and a term that early on when fish farmers were noting this disease and veterinarians working with it, it was just a name that was applied in the vernacular, calling it marine anaemia. It's not a very specific term and Dr. MacWilliams might be able to correct me, but I seem to recall very early on when the ISA disease, infectious salmon anaemia, came around some people referred to it as a marine anaemia, as well, too, and hence we really try to get away from using that term, marine anaemia, because it was not specific and it was also a lot of confusion resulted between this and infectious salmon anaemia, which causes severe anaemia.

So the more appropriate term is plasmacytoid leukemia and this is where we associate it with this particular retrovirus.

Q All right. Dr. MacWilliams, did you want to add anything to that?

DR. MacWILLIAMS: I concur.

Q Okay. Now, you call it in your paper salmon leukemia virus, Dr. Kent, but is it the case that there's a big question whether it's a virus?

DR. KENT: It's not really -- there's not a big question if it's a virus. The question would be is what the relationship of the disease. So we're going back about 20 years now before we had the sophisticated molecular methods that we could to pull out sequences, et cetera. So we identified -- this is working with a virologist, Dr. Bill Eaton at that time, with Malaspina College and working -- myself as a pathologist and working with a virologist so this is really work that he did as far as defining the virus. He used methods that you basically differentiate -- purifying material and differentiating and then running an assay called reverse transcriptase and at that time that was probably one of the better tools that we for identifying the presence of retroviruses and we also found viral particles that were consistent with retroviruses.

Third, we were able to transmit the disease with cell-free filtrates in the laboratory, so there were some pretty good evidence that there was a virus there. We didn't have as -- we've heard this term earlier today, quote the "smoking

gun". We weren't able to - Koch's postulates, that is, grow the virus in culture - reinfect fish and cause this leukemia-like condition.

It's well-known in the literature that retro -- one of the -- retroviruses may cause -- many infectious leukemias or related diseases are caused by retroviruses. But the problem is is that retroviruses are very common in animals and many retroviruses occur in animals that do not cause any disease. Many of these are endogenous retroviruses that basically are incorporated in the genome and are not causing any disease. So it's a more complicated answer than saying that we did not find a virus. We found a virus, but definitively if that was the cause of the disease, we didn't achieve that.

Q All right. I rather understand that in you, Dr. Kent, and in you, Dr. Stephen, we have two of the leading experts on this. You've done an awful lot of the writing between the two of you on salmon leukemia; am I right on that?

DR. KENT: I think so.

Q All right. You don't have to be modest.

DR. KENT: Okay.

Q And you agree, Dr. Stephen?

DR. STEPHEN: Yes, I do.

Q And do you have anything to add to what Dr. Kent was just saying?

DR. STEPHEN: If I can maybe expand a little bit on what he was talking about. I think that the -- it's important to distinguish between the findings of some of the molecular work on something like a retrovirus versus saying this particular disease is caused by this particular thing. I think Dr. Kent will mention that I think in your own experience, Mike, as well as others down in the States are finding a very similar, if not the same, disease with different organisms.

My research found that you could find marine anaemia or plasmacytoid leukemia in situations where there were other chronic inflammatory diseases. And, in fact, if I took the diagnostic slides to five different pathologists, the agreement between those pathologists was worse than flipping a coin and they had a hard time distinguishing between this being a cancer and chronic inflammation.

And again as Dr. Kent suggested, there are endogenous retroviruses and there's alternative hypotheses about this virus maybe, you know, that the animals are undergoing chronic inflammation that allows this virus to replicate that maybe didn't start it off; yet when you take that virus and then inject it into the belly of a fish in an experiment, which would be a very artificial way of doing it, it was able to cause the disease. So I think that it's very important to distinguish the pathology that they call plasmacytoid leukemia with these various potential causal pathways that cause that pathology.

Q What I think I'm hearing from both of you, and you two are amongst the leading experts as I understand it and writers on this, is that there's considerable uncertainty about this and no one is able to tie it to any disease so far. Is that a fair summary?

DR. KENT: Yes. As far as the so-called -- the salmon leukemia virus described by Bill Eaton and myself as a co-author, I just explain the associations of that and Craig, I thought, expanded on this -- Dr. Stephen expanded on this quite appropriately. I don't see any disagreement with what he's saying. And even added to that, this -- we're talking about cases that we obtained in the early -- late 1980s, early 1990s. As time went on, I'm going to follow up on some of the things that Dr. Stephen just said, there is a condition. It's a diagnosis, plasmacytoid leukemia is a presentation of cells and that could be caused by more than one agent, just like anaemia being caused by more than one agent. And, in fact, the later cases were more commonly associated with a parasite, *Neucleospora salmonis*, which we originally found in Washington State.

And, in fact, it was my former major professor at UC Davis was working more on the "parasite theory" and we talked quite frequently. He was trying -- it was this attempt to say well it's got to be caused -- this particular histological manifestation has got to be caused by one -- it's either the virus or the parasite. And we never really had that argument. It's a very convoluted story with this and so that's basically, I think, we've summarized it.

Hopefully it's not making things too complicated, but that's basically what the story is. It's a complicated ideology and the proliferation of immature blood cells can be caused by a number of different things.

So just like I think the easiest thing to say, well marine -- something that causes anaemia, multiple things are caused by anaemia. So we can't even state if the salmon leukemia virus -- is there some evidence of it as a cause of a plasmacytoid leukemia, it does not rule out other agents causing this type of lympho-proliferative disorder.

Q All right. Thank you. Moving along, Dr. MacWilliams, you spoke at the beginning of this afternoon about some of the protocols and fish health management practices that are in place in enhanced facilities to guard against and ward off disease from pathogens. Are there -- let's take the major facilities first. Are there operating manuals and protocols written down in place in those facilities?

DR. MacWILLIAMS: Yes. All the major facilities do have fish health management plans as a condition of licence.

Q And what sort of things would those fish health management plans cover? You've said a number of things that are done. Is that all in the manual?

DR. MacWILLIAMS: Yes. All of the biosecurity practices are in that manual. You can think of a fish health management plan as basically a biosecurity document. So that each plan has a number of standard operating procedures for gamete collection, brood stock selection, disinfection, what have you.

Q All right. What about the community facilities, what do they have by way of manuals or instructions or that sort of thing written down?

DR. MacWILLIAMS: The community facilities have a -- it's a small booklet with biostandards for culture rearing and some on how to do egg disinfection, how to do egg fungal treatments, densities and loading for the various species, so they also have a booklet that's very concise, but outlines the basics for fish culture for enhancement facilities.

Q And do they have -- do the community facilities

have access to the things that would go into a major facility's fish health management plan? Can they access that?
DR. MacWILLIAMS: Yeah. The CAs have all been given a copy of the template for the fish health management plans and we've done a couple of workshops on writing SOPs or standard operating procedures for the CADPs to encourage them to start writing down their own procedures of what they do in developing their own set of SOPs for operations.
Q You referenced a few moments ago to conditions of licence, that is the major facilities have to have fish health management plans as a condition of licence. As I understand it , all major facilities are licensed, are they?
DR. MacWILLIAMS: Yes, they are.
Q Is that true of the community facilities too?
DR. MacWILLIAMS: I'm not sure the state of the community facilities but if they aren't, they will be. And that would be a more appropriate question, I think, for the 31st.
Q Okay. That's fine. And I'm not going to get into the licensing here because you're quite right that there's another panel on that, but the whole idea of licensing of major facilities is new, is it?
DR. MacWILLIAMS: Yes. We've just been under licence conditions as of December 2010.
Q All right. Now, I may be going out on a limb here as to whether Mr. Lunn has the form of licence for major facilities. If you do... Oh, thank you.
If you have a look at that, Dr. MacWilliams, can you recognize that as being the form of licence for major facilities at -- if I'm right, it's a 21-page document and perhaps I should put a copy in front of you.
DR. MacWILLIAMS: No, that is the template for the --
Q Do you recognize the first page?
DR. MacWILLIAMS: -- enhancement -- the major facilities' licences, yes.
MR. TAYLOR: All right. May that be an exhibit, please?
THE REGISTRAR: Exhibit 1464 please -- 63.

EXHIBIT 1463: Salmonid Enhancement Program Aquaculture Licence 2010

MR. TAYLOR:
Q Now, Dr. Stephen, and when I read your report and went to the recommendations section there was an awful lot, 37 by my count. That appears to be quite a shopping list of things, many good ideas, but still an awful lot. Have you given any thought to focusing and prioritizing your recommendations?
DR. STEPHEN: Yes --
Q I think the -- sorry, just before I go to you, they start at page 99 of Exhibit 1454. Yes, Doctor?
DR. STEPHEN: Certainly. I think that what we attempted to do was to give not just thematic recommendations but some hopefully tangible steps. So while it looks like many, you'll notice many of them are sub-recommendations to go towards the major goals.
Q Right.
DR. STEPHEN: I think if I had to summarize those and distil them down, my first would be to get the fish health programs working on fish health, as opposed to their focus largely on pathogens and disease and largely for some of the reasons we've heard a bit of discussion on the panel today.
Q Now, just as you go through it and what you've just said is an example, are you able to tie what you just said to one of these numbers?
DR. STEPHEN: If you give me a copy of that, I certainly could go through them so I can skim through them if you'd like. But certainly recommendation number 2 is -- speaks right to that.
Q Yes. I will provide you with a copy of the recommendations of -- Dr. Johnson has got one for you there.
DR. STEPHEN: Thank you.
Q Page 99. It's just that it's going to help everyone, I think, if when you speak you can tie it to --
DR. STEPHEN: Absolutely.
Q -- one of your numbers. And you're quite right. You've got 11 main recommendations with by my count a total of 37 when you count --
DR. STEPHEN: Right.
Q -- all of the sub-points.
DR. STEPHEN: And the sub-points, as I say, were there

to hopefully give some sense of specific things we can do. So you can see as I talk about starting to think about health, we're talking about to do that there are things that have to be done, like making the management records available to people like Dr. MacWilliams, like making sure there's continuing education for folks, so they start thinking about health protection and promotion.

Q All right.

DR. STEPHEN: So that would be certainly one that I would go to that many of them could fall into that.

I think a second major one which I believe is under the research section -- let me just flip to it one moment. That would be recommendation 8 I think would be very important to think about what is the management target that we're working for for acceptable risk, which is why I was asking for some clarification on your question about what we're able to deem success. I think that would be a very important one for moving forward and it has only one sub-recommendation underneath there.

I think the other way I'd bring these together is I would like to see leadership really embrace and support a culture of research and practice that's holistic and integrative. An example of what Dr. Johnson brought up earlier, I think, is a fantastic step forward where the ecology folks and the water quality folks and the fish pathogen folks are starting to work together. And a number of our recommendations certainly deal with that.

Q Just, sorry to interrupt, but that's the three years starting in 2010 work that Dr. Johnson was referring to, you mean?

DR. JOHNSON: Yes, I believe that's what he's referring to. That's what I was referring to. A more holistic approach.

Q Okay. I'm sorry, Dr. --

DR. STEPHEN: No problem.

Q -- Stephen. Go on.

DR. STEPHEN: And you can see recommendation number 3 talked to that, so that we're not segregating salmon health by ownership or discipline. Sub-recommendations on 3 speak to that particular one.

The last one that I have, many of the other ones that I have are expansions on recommendation

1 1 of getting towards adaptive management, and
2 you'll see a number of the recommendations such as
3 having the capacity for applied research, so that
4 we can actually provide definitive evidence at
5 management plans or meeting or targets, that we
6 actually can manage and monitor, I should say,
7 wild fish so that we know that risk reductions are
8 being done. So while there are 37
9 recommendations, I think they would fall under
10 those major themes.
11 Q So I think, if I hear you right, you went 1,
12 recommendation 1, 8, 3, did I get that in what you
13 were going through just now?
14 DR. STEPHEN: 2 would be the one talking about focus on
15 health and resilience.
16 Q Or 2, 8, 3, sorry.
17 DR. STEPHEN: And 1 would be -- many of them would fall
18 under what would need to be done to do adaptive
19 management and let me just double-check the
20 number, 8 is the acceptable health standard would
21 be some priority, certainly.
22 Q Okay. Are you familiar, Dr. Stephen, with the
23 licence that major hatcheries now operate under
24 that we've just put in as an exhibit?
25 DR. STEPHEN: We were provided some copy of the Pacific
26 Aquaculture Regulations that talked about
27 licensing and we were provided one, I think, draft
28 of Big Qualicum Hatchery's and we focused only on
29 the fish health management plan with that.
30 Q Okay.
31 DR. STEPHEN: And it was no different than the other
32 versions of the fish health management plans we
33 were provided.
34 Q All right. Do those fish health management plans
35 then go some distance to meeting the kind of
36 recommendations that you're putting forward?
37 DR. STEPHEN: No. I think my recommendations more go
38 towards help bolster up our confidence that those
39 fish health management plans are meeting the goals
40 that we set out to get.
41 Q All right. Do you agree with the approach that's
42 being taken to now licence the hatcheries and put
43 conditions in the licence and put even more
44 stricture around the operations?
45 DR. STEPHEN: Sorry, you're saying "stricter" or
46 "structure"?
47 Q Well, both actually.

DR. STEPHEN: Okay. Well, it's important because I think more structure is important, especially as you've been alluding to with some of the community facilities. The reason I thought it was "stricter" is again because I don't -- I could not uncover the evidence that they're not sufficient as they are now. So that's why I wanted to make that clarification.

Q All right. Now, Dr. MacWilliams, the licence conditions and the protocols and so forth that hatcheries operate under may be seen as not as onerous as ones that salmon farms operate under; is that something that rings true with you or not?

DR. MacWILLIAMS: Yes. The licences for the varying levels, whether it's the finfish aquaculture, finfish enhancement or the -- actually, the major facilities, finfish enhancement or the public involvement finfish enhancement, there are three different levels -- or three different types of licences and they are constructed to demonstrate the differences between those practices and how they operate and what their goals are. So the licences for the enhancement programs are not as detailed as the aquaculture industry licence but it's a reflection of what we do and that we are releasing fish as juveniles. We're not holding them throughout their entire lives.

Q All right. And you're using native stocks to start?

DR. MacWILLIAMS: Yes. And we also -- yes, native stocks, native watersheds, and, yes.

Q As I understand it, a spawning channel or a hatchery at bottom is taking the local fish and putting them in your own facility as an egg to then hatch to get a fry to then send out to the same local environment again?

DR. MacWILLIAMS: Correct. Except I'd caution that a spawning channel, you're not actually taking eggs. You are just providing -- allowing them into a habitat to spawn naturally.

Q Yes. Thank you. Now, at Tab 11 of Canada's book of documents, there is a paper on ISA. Dr. Johnson, you're familiar with that paper, are you?

DR. JOHNSON: Yes, I am.

Q And Dr. MacWilliams, you are, as well?

DR. MacWILLIAMS: I am.

Q Okay. Are you knowledgeable, Dr. MacWilliams, on

the research on ISA as regards Pacific salmon?
DR. MacWILLIAMS: I would be very knowledgeable up to about 2006 and less so since then.
Q Okay. All right. This particular paper is at Tab 11 is one that is dated 2003, I think, by a -- is it Mr. or Dr. Rolland and Mr. or Dr. Winton? Either? Anyone? Can you answer?
DR. JOHNSON: It's Dr. Winton. I'm not sure about Dr. Rolland.
Q All right.
DR. MacWILLIAMS: It would be Doctor. But Jill is not Mr.
Q Okay. And what is the upshot or purport of this paper? What's it about and what does it conclude?
DR. JOHNSON: Dr. Winton and Dr. Rolland did a challenge in their Level 3 laboratory, which is a very high secure environment, laboratory with a very high level of biosecurity, where they investigated whether a virulent strain of ISAV would cause disease in Pacific salmon. They tested, I believe, chum and chinook and coho salmon and they used an artificial mechanism for infecting them, that is, they actually took virulent virus and injected these fish with it, rather than -- thereby bypassing sort of the normal route across the gills. If I remember the paper correctly, although they were able to generate disease in the Atlantic salmon both the species, all of the species of *Oncorhynchus* were -- did not develop disease, although I believe there was some instances where they could isolate virus from the fish at some point afterwards.
Q All right. Now, Dr. MacWilliams, you've mentioned that you have knowledge up to 2006 on ISA. Did you write a paper around about that time on it?
DR. MacWILLIAMS: I did.
MR. TAYLOR: Now, Mr. Lunn, do we have that paper available?
MR. LUNN: Yes.
MR. TAYLOR: This is a paper that was part of a letter that we sent in July to the various participants.
Q Is that your paper that you're thinking of, Dr. MacWilliams?
DR. MacWILLIAMS: It is. Yes.
Q And when was that written?
DR. MacWILLIAMS: It was actually written in 2006 but didn't get published until 2007.

MR. TAYLOR: Okay. And just to ensure we get all of this tidied up, can we mark the paper that I was at at our Tab 11 as the next exhibit, that's the paper by Rolland and Winton, please?
THE REGISTRAR: That's Exhibit 1464.

EXHIBIT 1464: Relative resistance of Pacific salmon to infectious salmon anaemia virus - Rolland and Winton

MR. TAYLOR: I thought we had a 1464. Okay. I'm told that's the correct number for this one.
And then next Dr. MacWilliams' paper that she just referred to from 2006, Morphologic description of infectious salmon ... and so forth, may that be the next exhibit, please?
THE REGISTRAR: 1465.

EXHIBIT 1465: Morphologic description of infectious salmon anaemia virus(ISAV)-induced lesions in rainbow trout *Oncorhynchus mykiss* compared to Atlantic salmon *Salmo salar* - MacWilliams et al

MR. TAYLOR: It's not a tab, it's an attachment to a letter from July that you all got. Thank you.
Q And Dr. MacWilliams, can you describe what you did and what you concluded in that paper?
DR. MacWILLIAMS: We did take a highly virulent strain of ISA from -- that had been isolated in an outbreak in a New Brunswick aquaculture facility and we amplified it through tissue culture and injected it into peritoneally or within the abdominal cavity of rainbow trout and Atlantic salmon and we characterized the disease that we saw there. And basically we were able to cause mortality and disease in the rainbow trout and we had chosen that species because it is of the genus *Oncorhynchus*, the same genus as the Pacific salmon species, and -- but fully understanding that Pacific salmon species have demonstrated increased resistance to the virus by previous researchers. And whereas we were able to under these very artificial circumstances create disease, it still became apparent that the disease in Atlantic salmon is -- in a natural setting ISA has only ever been found in marine farmed Atlantic salmon

and with marine farmed Atlantic salmon on this coast they are really a reasonable sentinel that if the disease were to be here and be present, you would see morbidity and mortality within that population much sooner than in any other population, using both my work and other literature reviews.

Q So just to be clear, when you say within that population, which population are you --

DR. MacWILLIAMS: The Atlantic salmon.

Q Atlantic salmon. And so if it was to show up in B.C. are you saying that you would see it in the salmon farms before anywhere else? Is that your --

DR. MacWILLIAMS: I would expect so, yes. And there has been ongoing surveillance previously in the province during their regulatory efforts and the auditing and surveillance program and I assume that will be ongoing under -- with DFO and fisheries aquaculture management.

Q And with that surveillance what's been found, if anything?

DR. MacWILLIAMS: There has been no indication of ISA or ISAV on this coast in B.C.

MR. TAYLOR: All right. Thank you. Those are my questions.

MR. MARTLAND: Mr. Commissioner, I have next on the list counsel for the Province of B.C. with 70 minutes.

MS. CALLAN: Mr. Commissioner, Callan, C-a-l-l-a-n, initial T.E., appearing on behalf of Her Majesty The Queen in Right of the Province of British Columbia.

CROSS-EXAMINATION BY MS. CALLAN:

Q My first set of questions are for Dr. Stephen. A hatchery that does not produce sockeye salmon is less a risk than a hatchery that does produce sockeye salmon; would you agree?

DR. JOHNSON: I don't think so, no.

Q Could you explain why?

DR. JOHNSON: Well, I think as you've heard, there's many of the pathogens that are equally shared amongst the different types of Pacific salmon and so it would depend on their root of exposure to begin with. Secondarily, being able to compare

risks is a challenging thing to do when we can't describe risks, so I keep coming back to that. And thirdly, it would also depend on the amount of the different animals being produced, the biosecurity of the facility and the release of the waste if at times when species of concern are going by.

Q So for part of your research you investigated three facilities operated by the Freshwater Fishery Society of British Columbia and specifically the Clearwater Trout Facility, the Fraser River Trout Hatchery and the Vancouver Island Trout Hatchery.

DR. JOHNSON: That's correct.

Q The Vancouver Island Trout Hatchery is on Vancouver Island?

DR. JOHNSON: Yes.

Q What are the chances of this facility's releases directly or indirectly transmitting disease to Fraser River sockeye?

DR. JOHNSON: Well, that can't be quantified on the data that's available. The biggest challenge we had with looking at the provincial facilities is we were only able to get some anecdotal explanations from Sherry Mead about the release patterns, so we weren't able to map where they released their fish to where that might overlap with sockeye habitat. So we weren't able to tell if that was going to be a situation where their fish were released.

Now, Ms. Mead did tell us that they don't release their fish into sockeye-bearing lakes or take their brood stock from lakes with sockeye salmon, so that would suggest there would be a lower opportunity for exposure. And given that they released their fish into lakes, it would further reduce that likelihood.

Q Now, the Clearwater Trout Hatchery is in Clearwater, British Columbia, that's halfway to the Alberta border?

DR. JOHNSON: Yes, if I recall.

Q And this is the only hatchery that you investigated that stocks Kokanee fish?

DR. JOHNSON: That I can't recall. I'd have to check, but as I recall, yes.

Q In your opinion, what are the chances that Kokanee release into -- by the Clearwater Hatchery would

directly or indirectly transmit disease to Fraser River sockeye salmon?

DR. JOHNSON: I think my answer would pretty much be the same for that Vancouver Island and the other hatchery, as well.

Q Okay. And you would agree though that Kokanee usually do not go into marine habitat or migrate down the Fraser River?

DR. JOHNSON: By definition, they should be lake-bound sockeye, yes.

Q So the only FFSBC hatchery in a Fraser River basin is the Fraser Valley Trout Hatchery?

DR. JOHNSON: Correct.

Q Okay. And this hatchery releases cutthroat, rainbow and steelhead trout?

DR. JOHNSON: I would have to confirm that with our report which species they...

Q Okay. And your opinion on risk would be the same as the other facilities?

DR. JOHNSON: Yes.

Q So if we could turn to page 3 of your report? And if we look at the bottom paragraph. I'm just going to read for us. It says:

> All major DFO and FFSBC hatcheries have Fish Health Management Plans that are intended to support the goal of not releasing fish with known infections. The Plans have not been audited. There are inadequate resources to allow fish health professionals to visit enhancement facilities to help adapt Fish Health Management Plans to local conditions, audit their practices and develop ongoing disease prevention programs.

I am advised by the FFSBC that they do have site-specific standard operating procedures and site-specific biosecurity checklists or self-audits derived from a general fish health management plan that addresses primary fish culture practices, fish health monitoring, accurate and current fish health records and diagnostic capability. Do you disagree with my understanding?

DR. JOHNSON: That was not within the documents sent to us and Ms. Mead told us that documents hadn't been audited and when we compared the three fish health management plans they had, they were pretty much

identical except for some background on the individual facilities.
Q Okay. And those would be the three tabs at the Province's book, the documents, Tabs 15, 16 and 17, are these documents that you reviewed?
DR. JOHNSON: I'd have to see what those tabs are. Do you have the documents there?
Q I have --
DR. JOHNSON: Okay. The fish health management plan documents, those are the ones we received.
Q So you have reviewed these documents?
DR. JOHNSON: I had Dr. Stitt for our team ran through them all himself and we talked about those, yes.
Q Okay. And if we could turn to page 12 of Tab 15 of the Province's book of exhibits and specifically s. 2.1. So this document says that:

> FFSBC Management and the FHU Section Head have undertaken biosecurity audits to identify areas of opportunities to improve or upgrade biosecurity systems. This audit was conducted in the Spring of 2007.

Is this new information to you?
DR. JOHNSON: No, I think we note that in the report that a biosecurity audit has been done, yes.
Q On page 57 of your report, you mentioned:

> The fish health staff at both laboratories did not appear to have regular access to production records...

I'm advised by the FFSBC staff that this is inaccurate and they have a database called PARIS that gives them access to the information. Are you in possession of any knowledge that would indicate that PARIS system does not provide staff with this information?
DR. JOHNSON: We were left with the impression with our interviews with the fish health staff that they had trouble getting that information regularly.
Q Okay. On page 53 of your report you mention that hatchery staff do not manage any suspected diseases on their own and instead are advised to contact the fish health staff. You would agree that bringing in fish health staff as soon as possible when disease is suspected is a good or,

you know, correct --
DR. JOHNSON: Yes.
Q -- way to operate?
DR. JOHNSON: Yes, I would.
Q On page 42 of your report you state:

> Modelling is used as a foundational tool in ecology and epidemiology. However, disease models have often been erroneous or imprecise in their capacity to predict disease events as was seen for foot and mouth disease in the United Kingdom, the spread and impacts of Mad Cow Disease (bovine spongiform encephalopathy) and AIDS, as well as the epidemiology of H1N1 influenza.

So my question is can you explain some of the limitations of mathematical modelling and provide just one or two examples related to disease in fish?
DR. JOHNSON: Now, I'm not a modeller myself, so it'll be a very broad overview and I guess what I'd like to say is with models -- mathematical models have been very informative for us to develop hypotheses about how diseases might act. Some of the population mechanisms that we talked about earlier, they have given us some very good insights into how we might attempt interventions such as a vaccine or treatment trial and they are used increasingly in public health to inform disease control as we go along. But they have constantly been challenged with the problem of finding out, you know, next month at this place at this time there will be this outbreak. And a lot of that comes from the nature of - as was alluded to earlier - the complexity of the systems and the fact they're dynamic and changing. So I mean as a broad overview, modelling, as I say, has been very, very important in both epidemiology and ecology for us to understand disease, disease processes in populations, but they have had some limitations in being able to predict specific events.
MS. CALLAN: Okay. And Mr. Commissioner, I would like to mark the exhibits at Tabs 15, 16 and 17 as the next three exhibits.
THE REGISTRAR: Number 15 will be marked as 1466;

number 16 will be 1467; 17 will be 1468.
THE COMMISSIONER: And what are they, Counsel?
MS. CALLAN: These are the fish health management plans of the Freshwater Fishery Society of British Columbia for three facilities that were investigated.

EXHIBIT 1466: Freshwater Fisheries Society of B.C. - Fish Health Management Plan Fraser Valley Trout Hatchery - November 2010

EXHIBIT 1467: Freshwater Fisheries Society of B.C. - Fish Health Management Plan Vancouver Island Trout Hatchery - March 2008

EXHIBIT 1468: Freshwater Fisheries Society of B.C. - Fish Health Management Plan Clearwater Trout Hatchery March 2008

MS. CALLAN:
Q Dr. Stephen, are you familiar with the Fish Health Audit and Surveillance Program operated from the Province between the years 2003 to 2010?
DR. STEPHEN: This is the audit program for...?
Q For fish health.
DR. STEPHEN: No, I didn't see -- I don't recall seeing specific data from that for this.
Q Well, not for this, but are you aware of the program generally in any of your dealings?
DR. STEPHEN: I'm -- again, I'm not sure of the name. Are you referring to what was done for the salmon farms by the Province or for the hatcheries?
Q No, for the salmon farms.
DR. STEPHEN: Oh, okay, then I have some awareness of that, a passing awareness, yes.
Q Okay. You provided some assistance in developing this program, I understand?
DR. STEPHEN: In the early days of development, yes, we did.
Q Okay. You critically reviewed the program when it was initiated?
DR. STEPHEN: Our group did, yes.
Q Okay. Can you provide me with a summary of your input into the program?
DR. STEPHEN: Oh, you're stretching my memory but I'll do my best. It was awhile -- I think initially we were consulted on how might one be able to do some

representative and defensible surveillance for disease patterns on salmon farms, given the challenges of resources and the concerns about confidentiality of the industry. So we worked with the Provincial -- I believe it was Dr. Constantine at the time to give them options about how they might be able to gather some of their surveillance data in a way that was hopefully as representative as you can get within those limitations.

Q Are you familiar with any other programs like it for any other food animal production industries in Canada?

DR. STEPHEN: I'm not aware of any ones that looked generally at a broad suite of diseases. There are a number of targeted programs in other sectors but I'm not aware of other ones in Canada like that.

Q Okay. And how does the British Columbia Fish Health and Auditing Surveillance Program as it was run by the Province until 2010 rank against other audit or surveillance programs in Canada with respect specifically to comprehensive coverage of disease in a food animal production industry?

DR. STEPHEN: Oh, we've never done that assessment so I couldn't give you any evidence on that.

Q Fair enough. And you probably couldn't rank it against other ones in those circumstances?

DR. STEPHEN: Well, I mean, in the very general sense, I think it's a very useful and helpful program that provides a significant amount more information than we'll see for other reproduction sectors. But that's in a very broad general sense.

Q Fair enough. Now, the food and agriculture organization of the United Nations website provides the following definition for freedom from disease and this is at the Province's Tab 4, and specifically it's the third paragraph.

DR. STEPHEN: Okay.

Q Okay. And it says:

> Generally speaking, accreditation of disease freedom is possible when there is no clinical, epidemiological or any other evidence of disease or agent of disease presence in an given period of time within a given geographical area. To validate such

claims adequate surveillance systems must be in place.

And I'll stop there.

DR. STEPHEN: Okay.

Q Okay. Would you agree that the British Columbia Fish Health Auditing Surveillance Program as it was in place until 2010 could provide the support for the designation of freedom from disease.

DR. STEPHEN: I would have to look at the numbers of the samples and how they were allocated before I could answer that. Declaration of freedom from disease is more complicated than this and, in fact, the FAO doesn't hold the authority but the OIE does and as you'll see in the following tab or table there , there are some specific requirements for specific diseases. And there's now a significant shift towards doing scenario-based assessment of freedom from disease, so you'd have to have a significant amount of data before making that decision.

Q Okay. And you're not aware of the data that the Province was holding?

DR. STEPHEN: You would have to look at it in details in terms of sample sizes, representation, geographic distribution, all those sorts of things before you can make that consideration.

Q Okay. And do you have any information on what numbers would generally be required?

DR. STEPHEN: No. It depends on population sizes, agreed-upon levels of confidence, all those sorts of things.

Q So if we could turn to the Province's Tab 3 -- I apologize. Sorry. The Province's Tab 2.

THE REGISTRAR: Did you wish to mark that Tab 4?

MS. CALLAN: Oh, yes. Actually, before we turn to that, I'll mark Tab 4 for the record.

THE REGISTRAR: It will be 1469.

EXHIBIT 1469: Supporting Claims of Freedom from Disease - UN FAO website extract

MS. CALLAN:

Q So this document summarizes the number of animals tested by PCR for infectious salmon anaemia virus. It also lists the publicly-available websites that contain this information. This table shows tissue

from 4726 fish which have been tested as part of this program over the last eight years and all test results have been negative. Would you consider these results to be sufficient evidence that B.C. has demonstrated freedom from ISA?

DR. STEPHEN: I couldn't elaborate on my last question -- or answer about the complexity of doing that with just the numbers. It will depend on the number of pens, the number of farms, the prevalence. There's a whole bunch of things that come into the concluding freedom from disease.

Q Okay.

DR. STEPHEN: Now, I can say that this is a significant number of animals. We look at some of our ongoing screening for endemic problems or food safety issues that might be done federally, this is a larger sample size than you'll see in a lot of other ongoing monitoring programs. But adequacy for freedom from disease would take some time to calculate and figure out.

Q I'd like to ask you a set of questions based on your expertise in epidemiology. You have provided advice for the development of several disease auditing, monitoring and surveillance programs around the world?

DR. STEPHEN: We have, yes.

Q Is it a standard part of you advice to include recommendations that source farm data be identified and all disease and veterinary records and that those records be made freely available to the public?

DR. STEPHEN: No, not for all cases that we worked on.

Q Have you ever recommended that?

DR. STEPHEN: I couldn't say with certainty. I could say with certainty if your objective -- the design of a surveillance system always depends on the objective. Sometimes we design things for individual agencies, sometimes for provinces, sometimes for nations. When you want a degree of public transparency, the importance in our view is to be able to demonstrate adequate representation as opposed to identifying sources for attribution. If your goal is for other monitoring for source attribution, then you have to have information. It's quite -- about the specific place. It's quite common for agricultural monitoring systems to not name the owner of the farm per se but give

it on a broader geographic basis and a lot of that comes from, you know, freedom of information and personal privacy legislation.

Q Would you recommend this?

DR. STEPHEN: For what purpose?

Q Well, would you recommend that farms be identified by source or do you recommend that in surveillance programs if there is disease that they do not be identified by source and rather are just identified by geographical area?

DR. STEPHEN: I think that it's important if you're doing surveillance to control the disease that somebody knows the source so that you can find it, you can trace it back. I don't know that -- it is not a matter of epidemiology to decide whether that information is publicly available. That's a public policy issue.

Q Okay. Would you agree that a program promising to share farm-specific disease records with the public might actually increase the chance that a disease outbreak would go undetected and possibly unreported?

DR. STEPHEN: Sorry? So you're saying do I agree that if a system identifies individual farms it would increase -- decrease the likelihood of detection? It depends on how you're detecting the disease. If you're requiring individuals to report, there can be problems as we've seen with things like avian influenza. Farmers are reluctant to report because of the large penalty to being found positive and we've seen submissions for poultry drop precipitously in a situation like that. If you're doing active surveillance where you have your own staff going out and looking, then it shouldn't have an effect.

Q Okay. Is there a generally-accepted worldwide standard related to disease surveillance programs in sharing of source farm information?

DR. STEPHEN: Not that I'm aware of.

MS. CALLAN: Mr. Commissioner, is this a good time for the afternoon break?

THE COMMISSIONER: Yes. Thank you.

THE REGISTRAR: Hearing will now recess for ten minutes.

(PROCEEDINGS ADJOURNED FOR AFTERNOON RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: Order. The hearing is now resumed.

CROSS-EXAMINATION BY MS. CALLAN, continuing:

Q And one last question with respect to the fish health auditing and surveillance programs. Can you name a specific surveillance and auditing program that does identify farm source?

DR. STEPHEN: Any species you're thinking of?

Q Yes.

DR. STEPHEN: Not publicly. Not off the top of my head, no.

Q Okay. Can you describe the differences between *Gyrodactylus* species and *Gyrodactylus salaris*?

DR. STEPHEN: Only very generally. I'm not a parasitologist. I mean, perhaps you want the parasitologist to answer that question.

Q Okay.

DR. STEPHEN: He'd be much better suited then myself.

DR. KENT: And Dr. Johnson might want to follow up. I'll give my answer, and I'm sure Dr. Johnson might be able to expand on that as well, too. There are hundreds of species of *Gyrodactylus*. They're pretty host specific, for the most part. That means they're only going to occur on, you know, on one genus of fishes or even particular species. The vast majority of them are moderately pathogenic, or -- are not that pathogenic and only become pathogenic in captive situations when water -- when the fish are crowded, et cetera. *Gyrodactylus salaris* is quite a different story. This one is pathogenic. In a unique situation it was introduced from Sweden into Norway and the Norwegian Atlantic salmon in that scenario were -- are highly susceptible to it and is associated with actual disease and mortality and wild salmon there, where most of the other *Gyrodactylus*, if I was, as a fish disease diagnostician, if I found a few *Gyrodactylus* species on a fish I wouldn't be too concerned about it.

Q Okay. So essentially, it's fair to say, then, that *Gyrodactylus* species is a general form of a parasite that is not very virulent, but the *Gyrodactylus salaris* is one variety of those species that is very virulent.

DR. KENT: Virulent, yes, that's right.

Q And there's no diagnostic test that's available for *Gyrodactylus salaris*, but there is one available for *Gyrodactylus* species?
DR. JOHNSON: Okay, actually, as part of the National Aquatic Animal Health Program, Dr. Abbott has done a large survey of *Gyrodactylus* species in British Columbia and actually in western Canada, and *Gyrodactylus salaris* is mentioned in the appendix that's associated with the ***Health of Animals Act***, and so there are now molecular diagnostic tests developed which will identify that species from all of the *Gyrodactylus species*.
Q And when was that developed?
DR. JOHNSON: Oh, over the last couple years.
Q Okay.
DR. JOHNSON: Year and a half.
Q And it's very uncommon for it to be tested in Canada?
DR. JOHNSON: I haven't -- I don't really know. It's not -- if it's -- if it is an issue of the CFIA, if they're interested in it, then they will decide on the testing regime.
Q Okay. And *Gyrodactylus salaris* has not been identified in British Columbia waters?
DR. JOHNSON: To my knowledge, it hasn't.
Q Okay. If you could turn to report 2010-1100 of the Freshwater Fisheries Society's case reports. This is in the Conservation Coalition's book of documents, and I believe it's Tab 1. If you look to the second paragraph, it says:

> Presumptive Findings: Bacterial Gill Disease is causing mortalities...

Would you agree that that's the cause of death in this particular case report?
DR. JOHNSON: I've actually, until this just -- this exact moment, I've never reviewed this case before. And I'm also not a veterinarian, so... Can we scroll to the top, please?
Q So if we could just scroll up a little bit as well.
MR. LUNN: This is the top of the page.
Q Yeah, it's under the Presumptive findings," so it's in the body with the last paragraph.
MR. LUNN: What would you like me to enlarge?
Q Starting from "Presumptive findings".

MR. LUNN: That's where I was, and the witness asked me to scroll up.
MS. CALLAN:
MR. LUNN: So I'm just trying to accommodate.
DR. JOHNSON: I don't know and...
DR. KENT: I can make a comment on this. So I guess I'm reading the report, 30 out of 30 were positive for bacteria consistent with the agent that causes Bacterial Gill Disease, that's a reasonable presumption. Bacterial Gill Disease is well known to be associated with negative water quality conditions. The diagnosis from this, what I'm reading here, sounds reasonable. Dr. MacWilliams, she probably deals with this kind of thing all the time. She might want to expand on that.
DR. MacWILLIAMS: No, that looks fine. I just can't read the bottom of the page where it mentions *Gyrodactylus*.
Q Yes. If you'd scroll -- there is -- I'll get to that. I'm advised by the Freshwater Fisheries Society that a clerical error was made and the test for *Gyrodactylus* species was inputted as *Gyrodactylus salaris*, and I understand the Conservation Coalition will be making some use of this. So my question to you, because I'm advised by the Freshwater Fisheries Society that this was a clerical mistake is, based on your expertise looking at this, is bacterial kidney -- or, sorry, is Bacterial Gill Disease more likely than the *Gyrodactylus salaris*?
DR. KENT: It would depend on the severity of the *Gyrodactylus* infection. And actually, *Gyrodactylus* generally occurs on the skin, whereas *Dactylogyrus* would normally occur in the gills, so I'm kind of questioning that diagnosis as well, too. But that aside, it's a numbers game with parasite infections, regardless of the precise diagnosis. Seeing a lot of numbers of monogenes on the gills would also support water quality conditions that were suboptimal so that seeing gill monogeneans, presumably *Gyrodactylus* as I report here, would not be surprising to see these co-infections with Bacterial Gill Disease. Sorting out which one is the primary cause and which one is the secondary, that would be rather difficult. I think I see 50 percent, if that's what I'm seeing, 50 percent were infected with the

Gyrodactylids; the monogenes, a hundred percent with the Bacterial Gill Disease, so probably the Bacterial Gill Disease was more important at that point.

MS. CALLAN: Okay. And Mr. Lunn, I provided you with a document on the break.

MR. LUNN: Yes.

MS. CALLAN: Could you turn to the page -- the document from the Freshwater Fisheries Society?

MR. LUNN: I don't have that as available electronically. I only have your hard copy.

MS. CALLAN: Okay.

MR. LUNN: I can hand that up, if you'd like, or --

MS. CALLAN: I have copies, so I can hand that out as well.

MR. LUNN: Certainly.

MR. MARTLAND: Mr. Commissioner, I just want to slow down to this extent, that we're being handed something in real time, but sometimes it's emailed the day of. I don't know who's seen this and whether counsel have seen it or can take a position on the fly. Perhaps this is something, if Ms. Callan is able, to leave this down the list of questions. At least counsel receiving the paper now will have the opportunity to lead it.

MS. CALLAN: My understanding is the Aquaculture Coalition got a similar letter that sets out the same information from myself. I have handed this copy as well to the Conservation Coalition, as well as the same letter that was sent to the Aquaculture Coalition that sets out the information.

I just want to clarify a mistake before it gets brought up in cross, so I'm just trying to anticipate my friends' crosses, and I wasn't aware of this until I reviewed the documents that the Conservation Coalition was relying on, on the weekend.

I can leave this till the morning, though, if that makes it easier. In the interim, I'd like to mark Tab 1 of the Conservation Coalition's book of documents as an exhibit.

THE REGISTRAR: Exhibit 1470.

EXHIBIT 1470: PARIS Fish Health Case Details, Case 2010-1100 Diagnostic, for

Little Campbell River Hatchery, dated February 14, 2011

MS. CALLAN: And I would also like to mark Tab 2 of the Province's book of exhibits as well as the next exhibit.
THE REGISTRAR: What tab was that again?
MS. CALLAN: Tab 2.
THE REGISTRAR: Tab 2 will be 1471.

EXHIBIT 1471: Publicly available PCR test results for ISAV in British Columbia farmed salmon from 2003-2010

MS. CALLAN:
Q If we could move onto another subject, and tomorrow we'll revisit whether or not the letter can be marked as an exhibit, Dr. Kent, you've concluded that no specific pathogen is a major cause of demise to the Fraser River sockeye salmon?
DR. KENT: No, that's not -- I've concluded that we cannot identify a specific pathogen to be the cause of the demise of that. In making that conclusion, based on the lack of data - I know this may seem like splitting hairs - but I'm not saying we've excluded the possibility that a single pathogen is the cause of the demise of sockeye salmon.
Q That's fair enough. I wouldn't want to put words into your mouth. Prolonged changes in water temperature either in freshwater or seawater can be a significant factor to the demise of Fraser River sockeye salmon?
DR. KENT: Well, I'm not a -- this is getting a little bit outside my area, but that seems to be a reasonable -- a reasonable statement, and that it is well known that temperatures really do play a very significant role on the proliferation of pathogens in and outside of their host, as well as immune status of the host, the salmon host. An example would be, we always talk about temperature affecting salmon and they have their cold water species, they like to be in cool water. You can have a situation where the waters are quite warm, but in the absence of pathogens the fish are doing relatively okay. If you add pathogen on top of

warm water, and then you can see problems with that.

Q Would you agree that considerable differences in virulence and lethality can occur when a pathogen infects different salmon species or in different environmental conditions and thus linking these diseases with potential problems and wild sockeye salmon should be made with some caution?

DR. KENT: Yes.

Q Now, I understand that lab studies can provide the basis of a hypothesis. For example, if lab exposure to ISAV kills Atlantic salmon but not Pacific salmon, you can hypothesize that ISAV is a greater risk to Atlantic salmon than Pacific salmon; would you agree with that?

DR. KENT: I would agree with that.

Q Now, when you created your subjective levels of risk, did you use a standard risk analysis matrix, such as consequence times probability, or is it more subjective?

DR. KENT: It was more subjective that, and as I said at the beginning of our hearings today, I guess, in retrospect, it would have been better to say, "high impact/low impact/moderate impact" instead of using the term "risk", because I was using the term "risk" in a different context than epidemiologists and some others might use it in.

Q Okay. So I'm going to move onto the topic of sea lice for a few moments. Would you agree that *L. salmonis* are marine copepods that are not found in water below a certain salinity?

DR. KENT: That's my understanding, yes.

Q And that *L. salmonis* infection in pink salmon causes mortality only in fish less than 0.7 grams and when subject to high concentrations of lice?

DR. KENT: That's my understanding from review of the literature. And actually, Dr. Johnson, if I'm wrong, he's the expert on sea lice, so if he sees I'm making an error, I would not be offended if he corrects me or chimes in and expands on the questions.

DR. JOHNSON: Yes, that 0.7 gram was based on the work of Dr. Jones, who will be testifying on the sea lice.

Q Okay. And if we could turn to the Conservation Coalition's Tabs 17 and then 19, but we'll start

with 17. Would you agree that this is the scientific paper that forms the basis of this?
DR. KENT: I believe so.
MS. CALLAN: Mr. Commissioner, can we mark this as the next exhibit?
THE REGISTRAR: Tab Number 17 will be marked as 1472.

EXHIBIT 1472: Journal of Fish Diseases, 2008, Early development of resistance to the salmon louse, *Lepeophtheirus salmonis* (Kroyer), in juvenile pink salmon, *Oncorhynchus gorbuscha* (Walbaum), by S. Jones, E. Kim and W. Bennett

MS. CALLAN: And if we could turn to Tab 19, now.
Q Is this also authority for the same point?
DR. JOHNSON: Yes, I believe so, it is.
MS. CALLAN: Mr. Commissioner, could we mark this as the next exhibit?
THE REGISTRAR: Tab 19 will be marked as 1473.

EXHIBIT 1473: Diseases of Aquatic Organisms, Infection Threshold to estimate *Lepeophtheirus salmonis*-associated mortality among juvenile pink salmon, by Simon Jones and Brent Hargreaves

MS. CALLAN:
Q Now, you would agree that when sockeye smolts are doing their outmigration, they are substantially larger than 0.7 grams and that generally they're between 20 and 50 grams?
DR. KENT: They're way -- they're much larger than 0.7. I'm not sure 20 or 50. That seems about -- I would say around 20, just depending on the run, et cetera. Maybe my colleagues can expand on that, but somewhere around 20 grams. Yet, yeah, basically 20 times the size of that 0.7 grams, at least.
Q Would you agree that's a reasonable hypothesis that *L. salmonis* is not a significant source of mortality, then, for sockeye smolts?
DR. KENT: It's a reasonable hypothesis at this time, that's why I put it at a lower -- I assigned it to a lower impact or risk -- risk level. That was based largely on that. Dr. Johnson has something else to add to that.

DR. JOHNSON: Yeah, the majority of sea lice that had been found on the sockeye salmon, onto the genus *Caligus, Caligus clemensi*, so that's not -- *Lep. Salmonis* is the least abundant of the different species of sea lice found on sockeye in the studies that I'm aware of and in our work on Georgia Strait.

Q Thank you. In your experience with DFO in the 1990s, were you aware of situations in which sea lice, and specifically *L. salmonis*, infested Atlantic salmon in sea farms?

DR. KENT: I guess this would be for me. Yes, yes, I'm aware of infestations. I'm not aware of any catastrophic outbreaks to the -- for the farms that I was working with, but certainly the work that I was doing on farms, I would find sea lice on farms. I can't give you -- at that time, there wasn't much as interest in sea lice, and it was more or less an incidental finding in contrast that was what had been seen more or less around the same time on the east coast.

DR. JOHNSON: I can remember one instance where there was heavy enough lice load on fish in the Sunshine Coast which necessitated the sea lice treatment. Effectively, I stopped working on sea lice in B.C. because it simply wasn't an issue. When I -- after I finished my PhD I went on and did other things. There were always sea lice presences, as Dr. Kent said, but they were at levels which didn't cause any harm to the animals that were being cultured.

Q So it's fair to say, then, that sea lice infestation of farmed Atlantic salmon in the 1990s was fairly common?

DR. JOHNSON: I would say that in the 1990s, based on my recollection of being able to go to salmon farms to collect sea lice, it was easier to find sea lice on salmon farms in the 1990s than it is now, because of the use of SLICE treatments.

Q Dr. Johnson, you published a scientific paper in 1993 on the efficacy of sea lice treatment on Atlantic salmon, and this is at Provincial Tab 8?

DR. JOHNSON: Yes, that's my paper. Sorry, I was just trying to look over my glasses to read it.

MS. CALLAN: Okay. If we could mark this as the next exhibit.

THE REGISTRAR: 1474.

EXHIBIT 1474: Diseases of Aquatic Organisms, Efficacy of evermectin for control of the salmon louse *Lepeophtheirus salmonis* on Atlantic salmon, by S.C. Johnson and L. Margolis

MS. CALLAN:

Q Was your research done in response to the perceived need from the B.C. Aquaculture industry because they had fish that were infested with sea lice?

DR. JOHNSON: No, I -- this research sort of stemmed out of my interest in possible routes of parasite control, more as -- more related to the global issue that was being experienced in other parts of the world than in British Columbia.

Q And you'd agree that salmon, *L. salmonis*, in British Columbia or the Pacific ocean waters is genetically different from *L. salmonis* in the Atlantic ocean?

DR. JOHNSON: If you look at the work that Dr. Ben Koop and I -- and Dr. Jones is involved with, and he'll be on the stand, there is good evidence that there are considerable genetic differences or sequence differences between the Pacific and the Atlantic form of *Lepeophtheirus salmonis*.

Q Okay. Now, I'm just going to turn to an issue with respect to sea lice in the 1990s. Several scientific papers without access to provincial or federal or farm sea lice data, for example, Brendan Connors' 2011 paper, which is set out at Provincial Tab 14, claim that sea lice infestations of wild salmon began in 2001. In contrast, another scientific paper that had access to the provincial sea lice data published by Dr. Marty in 2011 claimed that farm-sourced sea lice probably infested juvenile pink salmon many years before the pink salmon were first examined for sea lice in 2001. Which one of these assumptions best fits your experience with sea lice in British Columbia during the 1990s?

DR. JOHNSON: As I mentioned, in the 1990s, sea lice were always present on salmon farms at levels which made it worthwhile going to the salmon farms to collect sea lice. Now, it's extremely difficult to do sea lice research in B.C., because it's often difficult, unless you go to wild fish

when they're returning, to get sufficient sea lice from a salmon farm to conduct any sorts of studies on sea lice.

MS. CALLAN: Okay. If we could mark Provincial Tab 14 as the next exhibit.

THE REGISTRAR: 1475.

EXHIBIT 1475: Journal of Applied Ecology, Coho salmon productivity in relation to salmon lice from infected prey and salmon farms, by Brendan Connors, Martin Krkosek, Jennifer Ford, and Lawrence Dill

MS. CALLAN:

Q Dr. Johnson, have you read the paper, Sea Louse Infection of Juvenile Sockeye Salmon in Relation to Marine Salmon Farmers on Canada's West Coast? This is set out at Provincial Tab 23.

DR. JOHNSON: Yes, I've read the paper by Mr. Price.

Q This paper suggests that sea lice levels on sockeye were greatest closest to salmon farms; would you agree?

DR. JOHNSON: I have a few issues with this paper and the companion paper which dealt with pink and chum salmon. It's very interesting, if you look at the maps that they provide in those two papers, they're essentially the same map, but sites which are being identified as being highly impacted or not impacted differ between the two papers. So it's a bit unclear to me as to how they actually assigned these -- whether the sites were heavily impacted or not. And I also disagreed a bit - this is based on my memory - of the exclusion of one site, which was far away from the outside of their range of salmon farms, because the sea lice counts were abnormally high, according to those authors.

The other thing that I worried about was the fact that for their comparison they used fish that were caught by a completely different method, if I'm not mistaken, and fish from a completely different environment which was, I believe, up just south of the Skeena.

Q You were anticipating most of my questions.

DR. JOHNSON: Well, this is what I read into this paper when I looked at it. I think it's really

important to compare this one to their other paper on pink and chum.
Q Okay. So you would agree that this paper excluded sockeye caught in outlier sites amongst the Discovery Islands?
DR. JOHNSON: It excluded sockeye caught downstream from a fish processing plant in only one of the years that they studied it. And I'd like to say that we do get similar sea lice counts on fish, on sockeye salmon, in the Strait of Georgia, but there's also -- we get some big sea lice counts of fish caught from much further south than the Strait of Georgia. But, of course, the work that we're doing is in a different year than these authors did.
Q Okay. Now, they say they had the furthest -- the highest level of sea lice was furthest away from the salmon farms?
DR. JOHNSON: If I remember correctly, it was the furthest away, but downstream from a processing plant.
Q Now, my understanding is actually upstream from --
DR. JOHNSON: Or okay, I'm sorry. I'm thinking down is down a bit. Yes, upstream from the processing plant.
Q Okay. And I understand their theory was that the salmon processing plant was the cause of the infection?
DR. JOHNSON: I believe that was the theory that they proposed.
Q And it was approximately eight kilometres upstream; do you agree with this suggestion that the authors of the paper put out?
DR. JOHNSON: I have no knowledge about what the salmon plant was processing, if anything, at the time the study was done. And it would be interesting that if it was -- needed to be excluded in one year, why didn't it need to be excluded in the subsequent year?
Q And you'd agree that it's highly unlikely that the sea lice were actually swimming upstream eight kilometres to infect the salmon?
DR. JOHNSON: I think that this whole study of this area is -- needs to consider the fact that there are tidal flows that go in both directions. And if I remember correctly, from the physical oceanographers, that these tidal flows cover this

whole area that these papers talk about in both a north and a south direction. So this area is actually fairly well mixed, although, as I understand, the major direction of water is northwards, but on the tidal changes you can have water going kilometres south and then kilometres back north. So I don't think that it -- it would be very hard for me, as an individual, to say which sites in this area were impacted from salmon farms based on that high level of tidal mixing.

Q Okay. Now, I understand that the author also compared with the north coast. Would you agree that this comparison is quite weak because of the differing salinity levels?

DR. JOHNSON: I was more concerned, if I remember correctly again, that there was a switch in the type of gear that was used. And in one of the papers they did express some concern, I believe, that some lice were potentially under-sampled. I can't remember exactly where it is.

Q Okay. Now, if we could turn to Figure 3 of Provincial Tab 23. Would you agree that it shows sea lice levels were higher in 2008 than in 2007?

DR. JOHNSON: Figure 3? Okay. I'm sorry, I have a hard time seeing with these multi-focal lenses.

Q Yeah, so if you actually look to the --

DR. JOHNSON: Yeah.

Q -- figure it says that the solid line is 2007 and the dotted line is 2008.

DR. JOHNSON: It would appear to me that the levels were higher in 2008, but I would like to point out that the actual abundance that we're talking about is extremely low, ranging from zero to 0.2 sea lice per fish.

Q Okay. That's a very good point as well. Would you agree that because the sea lice levels were higher in 2008 than 2007, that means that the outmigrating fish for the 2010 adult returns had higher levels of sea lice than in 2008 adult returns?

DR. JOHNSON: I can't say that that would be for all of the fish which were outmigrating. For the fish that they sampled, that would, to me, appear to be the case. But if you'd gone out two weeks later, I don't know what you would have found.

Q Okay. If we could turn, now, to the topic of IHN, and my questions will be directed to Dr. Kent.

In your report, you state that sockeye smolts have a high risk exposure to IHN in both freshwater and marine environments, and this is set out on page 19 of your report?

DR. KENT: Okay.

Q Would you agree that sockeye, once they enter seawater, are not as susceptible to IHN as compared to when they're in the freshwater, as smolts and fry?

DR. KENT: Yes, I would agree with both that as relates to their size susceptibility, and probably -- and certainly, from what we know about where IHN concentrations of IHN in spawning grounds, et cetera, I would assume that they're also going to be exposed to less virus in the marine environment than they would in freshwater. So they have two things going for them in the marine environment; they're larger at that time, and they're also going to be less -- I would -- I'm not a virologist - Dr. Garver could probably expand on this - but I'm pretty confident that there's much lower concentration of IHN virus in the marine environment than there is in the freshwater environment.

Q Now, on page 5 of your report you said Traxler, in 1993, showed that while field observation of clinical disease is confined to fry, experimental exposure of 20 gram sockeye salmon in seawater result in low mortality than cohabitated with infected fish?

DR. KENT: Yes.

Q Okay. Is that statement perhaps a tad bit overstated, or...?

DR. KENT: Well, I could expand on that. It's basically this gets back to some more discussions earlier today about comparing lab studies to field studies. What this does tell us is that larger sockeye salmon are capable of becoming infected by cohabitation with infected fish. I was actually involved with the study, I think I'm a co-author on this paper, where these are basically done in marine tanks in much closer proximity with infected fish than they would be in a wild situation.

Q Okay. And certainly in those two experiments both yourself and Dr. Traxler had one tank of injected Atlantic salmon and one tank with injected sockeye

salmon, so actually infected by injection with IHN?

DR. KENT: Right.

Q And they were put in there for -- with 25 uninfected sockeye salmon in each sample group, so two tanks, and 25 uninfected sockeye with other fish that had been injected with IHN?

DR. KENT: If I recall, that was going on 20 years ago when we did this study, but I mean, I've written some 200 papers on fish diseases, I'll try to remember this one, but they -- that the donor fish, I agree with you, that if I seem to recall, that the donor fish were established by injecting them with virus so that we would know that they would be shedding a large a number of virus and then cohabitated them with other fish.

Q Okay. And of all of the sockeye that died, there was actually only one that died?

DR. KENT: Yeah, that seems to be -- that seems to be consistent with my recollection.

Q Okay. And that would not be statistically consistent with zero?

DR. KENT: I would imagine it's not statistically different. Again, what I'm saying is what this study showed is that sockeye salmon of this size under extreme conditions one could conclude from these lab situations, are capable of becoming infected and dying from IHN.

Q Okay. Would you agree, then, that perhaps stating it was a higher risk in saltwater should be modified to moderate?

DR. KENT: Well, the reason why I -- and maybe I would be fine with either way. This is a problem with this subjectivity that we have here. I also understand that there's some new work being done at Pacific Biological Station, where they're showing some variability in subtypes of, you know, the type of virus and the strain of IHN virus that occurs in B.C., that there is some variability, even within that one single strain in the virulents, so that would be one concern.

So one could conceive of the scenario of a much more pathogenic virus in the marine -- IHN virus in the marine environments. The IHN virus is an RNA virus and these types of viruses are well known to mutate very quickly and change in their pathogenicity quite rapidly. So it's something

that I would put it on the high -- potentially high impact to put it on the warning for, you know, if I was going to direct people to be looking at potential pathogens is to keep IHN on the list for fishes in the marine environment.

Q Okay. And Dr. Johnson, do you agree with that statement?

DR. JOHNSON: I agree that I think that IHN virus has a -- could play a role in sockeye population dynamics. I'm not sure about the rate at which it mutates. As I understand it, there is only a single genotype found in sockeye salmon at this time in B.C., yeah. I should say in all of B.C.

DR. MacWILLIAMS: I would add that you mentioned there may be work being done with different strains at the biological station. That's not correct. The only work that we're doing is with the endemic strain in B.C. The areas of strain that's been shown in Washington that's showing increased virulents for steelhead populations, cultured steelhead populations, but that's not a strain that we have in British Columbia.

DR. KENT: Okay, thank you.

Q Would you agree, though, that Atlantic salmon are much more susceptible to IHN than sockeye salmon?

DR. KENT: Yes, Atlantic salmon are much more susceptible to IHN than Atlantic salmon -- I mean, Atlantic salmon are much more susceptible than sockeye salmon.

Q Perfect. There are a no reported cases of IHN in salmon farms in the last five years, that you're aware of?

DR. KENT: I think others that are actively working in B.C. could respond to that better than I can.

DR. JOHNSON: As far as I'm aware, there's no reported cases of IHN in salmon farms in British Columbia in the last five years.

MS. CALLAN: I note the time, we're at four o'clock. If the Commissioner wants to break for the day, I can start again tomorrow.

THE COMMISSIONER: Thank you.

THE REGISTRAR: Ms. Callan, did you wish to mark your Tab 23?

MS. CALLAN: Thank you for that, if we could mark Tab 23 as the next exhibit?

THE REGISTRAR: Yes, that will be 1476.

EXHIBIT 1476: Sea Louse Infection of Juvenile Sockeye Salmon in Relation to Marine Salmon Farmers on Canada's West Coast, by Michael Price, et al

MS. CALLAN: And if we could also mark Provincial Tab 7, which is the paper that we were talking about, the IHN, as the next one?
THE REGISTRAR: 1477.

EXHIBIT 1477: Diseases of Aquatic Organisms, Transmission of infectious hematopoietic necrosis virus in seawater, by G.S. Traxler, J.R. Roome, and M.L. Kent

THE COMMISSIONER: Which tab was that, I'm sorry?
MR. LUNN: Tab 7 was the last one --
THE COMMISSIONER: Of B.C.'s? Of their documents? All right.
MS. CALLAN: That's right. It's the document entitled, Transmission of infectious hematopoietic necrosis virus in seawater.
THE COMMISSIONER: Thank you. We're then adjourned until tomorrow morning?
THE REGISTRAR: The hearing is now adjourned until ten o'clock tomorrow morning.

(PROCEEDINGS ADJOURNED TO TUESDAY, AUGUST 23, 2011, AT 10:00 A.M.)

I HEREBY CERTIFY the foregoing to be a true and accurate transcript of the evidence recorded on a sound recording apparatus, transcribed to the best of my skill and ability, and in accordance with applicable standards.

_____
Pat Neumann

I HEREBY CERTIFY the foregoing to be a true and accurate transcript of the evidence recorded on a sound recording apparatus, transcribed to the best of my skill and ability, and in accordance with applicable standards.

_____

Susan Osborne

I HEREBY CERTIFY the foregoing to be a true and accurate transcript of the evidence recorded on a sound recording apparatus, transcribed to the best of my skill and ability, and in accordance with applicable standards.

_____

Karen Hefferland