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:

Room 801
Federal Courthouse
701 West Georgia Street
Vancouver, B.C.

Tuesday, March 8, 2011

Tenue à :

Salle 801
Cour fédérale
701, rue West Georgia
Vancouver (C.-B.)

le mardi 8 mars 2011

APPEARANCES / COMPARUTIONS

Patrick McGowan Jennifer Chan	Associate Commission Counsel Junior Commission Counsel
Mitchell Taylor, Q.C. Geneva Grande-McNeill	Government of Canada ("CAN")
Boris Tyzuk, Q.C. 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")
David Bursey	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. Lisa Glowacki	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 c Foundation ("CONSERV")
Don Rosenbloom	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")
Christopher Harvey, Q.C.	West Coast Trollers Area G Association; United Fishermen and Allied Workers' Union ("TWCTUFA")
Keith Lowes	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 Leah Pence	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")
No appearance	Métis Nation British Columbia ("MNBC")

APPEARANCES / COMPARUTIONS, cont'd.

No appearance	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")
No appearance	Heiltsuk Tribal Council ("HTC")

TABLE OF CONTENTS / TABLE DES MATIERES

EXHIBITS / PIECES

Vancouver, B.C./Vancouver (C.-B.)
March 8, 2011/le 8 mars 2011

THE REGISTRAR: Order. The hearing is now resumed.
MR. McGOWAN: Good morning, Mr. Commissioner. Today and tomorrow have been set aside in the hearings to deal with one of the science reports that your counsel commission, that's Project 9, dealing with the impacts of climate change.

We have here, today, Dr. Scott Hinch and Dr. Eduardo Martins, the two authors of the report, who are here to give evidence to you on its contents. I don't have anything else to say before we get into commission counsel's examination, so perhaps the witness (sic) could be sworn?

THE COMMISSIONER: You'll have to put yourself on the commission as well as your learned friend.
MR. McGOWAN: Yes, thank you. Patrick McGowan, counsel for the commission.
THE COMMISSIONER: And...?
MR. McGOWAN: Jennifer Chan. Thank you, Mr. Commissioner.

EDUARDO MARTINS, Affirmed.

SCOTT HINCH, Affirmed.

THE REGISTRAR: State your name, please?
DR. MARTINS: Eduardo Martins.
DR. HINCH: Scott Hinch.
THE REGISTRAR: Thank you. Counsel?
MR. McGOWAN: Thank you, Mr. Commissioner. I'm going to commence by taking the witnesses through their CV's, their qualifications, and I'm going to seek to have them qualified as experts. I'll start with Dr. Hinch, Mr. Commissioner, and I'm going to seek to have him qualified as an expert in the area of aquatic ecology.

Could we have the CV brought up, please?

EXAMINATION IN CHIEF BY MR. McGOWAN:

Q On the front of the -- on the screen in front of you, sir, that's the first page of your CV?
DR. HINCH: Yes.
Q The first of quite a number of pages?

DR. HINCH: Yes.
MR. McGOWAN: And perhaps we could have that marked as the next exhibit? I'll take the witness through it.
THE REGISTRAR: Exhibit 551.

EXHIBIT 551: *Curriculum Vitae* of Dr. Scott Finch

MR. McGOWAN: Thank you.
Q Sir, you've completed a PhD in aquatic ecology?
DR. HINCH: Yes.
Q And you took that degree within the zoology department at the University of Toronto in 1992?
DR. HINCH: Yes.
Q I wonder if you could just briefly explain to the commissioner what aquatic ecology is?
DR. HINCH: Aquatic ecology is the study of the distribution, abundance and behaviour of aquatic organisms in the context of the environment they live in.
Q Okay. And is the topic of fish biology subsumed within aquatic ecology?
DR. HINCH: Yes.
Q Okay. In addition to your PhD, you hold a bachelor of science and a master of science, both from the University of Ontario?
DR. HINCH: University of Western Ontario.
Q Western Ontario, thank you. You're a professor, presently, at the University of British Columbia?
DR. HINCH: Yes.
Q In which department?
DR. HINCH: Forest sciences.
Q Okay. And how long have you held that position?
DR. HINCH: Since 1994.
Q Okay. You've taught dozens of courses at UBC?
DR. HINCH: Yes.
Q Including in the areas of fisheries, science, aquatic biology and conservation sciences?
DR. HINCH: Yes.
Q Okay. You've supervised many graduate students and undergraduate thesis?
DR. HINCH: Yes.
Q You've published hundreds of peer-reviewed articles and presented at many international conferences?
DR. HINCH: Yes.

Q The studies and research that you conduct are primarily in the areas of aquatic ecology and fish biology?
DR. HINCH: Yes.
MR. McGOWAN: And I wonder if we could just bring up the top of page 3 of the CV, please?
Q And the three bullet points at the top of that page, sir - I won't read them all out to you - but they identify your primary areas of research?
DR. HINCH: Correct.
MR. McGOWAN: Okay. Mr. Commissioner, I'm going to ask that the witness be qualified as an expert in aquatic ecology.
THE COMMISSIONER: Thank you, Mr. McGowan. I take it there are no other participants who wish to raise any objection to this application for qualifying the witness? Very well, thank you, Mr. McGowan.
MR. McGOWAN: Dr. Martens, I'm going to take you through your CV as well, and perhaps we can have that brought up.
Mr. Commissioner, I'm going to seek to have Dr. Martins qualified as an expert in population ecology.
Q Sir, this is the first page of your CV?
DR. MARTINS: Yes.
Q Okay. And that's a copy, a full copy you provided to the commission, and Mr. Commissioner, it's in the system electronically.
DR. MARTINS: Yes.
MR. McGOWAN: I wonder if that could be marked as the next exhibit, please.
THE REGISTRAR: Exhibit Number 552.

EXHIBIT 552: *Curriculum Vitae* of Dr. Eduardo Martins

MR. McGOWAN:
Q Dr. Martins, your PhD is in ecology, and it was completed in 2007?
DR. MARTINS: Yes.
Q And the focus of your thesis for your PhD was on population ecology?
DR. MARTINS: Yes.
Q I wonder if you could just explain to the commissioner what population ecology is?
DR. MARTINS: Yeah. The study of distribution of abundance of populations.

Q Okay. And that goes beyond just marine species; is that correct?
DR. MARTINS: Yes.
Q You also hold a bachelor of science in biology?
DR. MARTINS: Yes.
Q And a masters of science in ecology?
DR. MARTINS: Yes.
Q Okay. And you're currently doing a post-doctoral research at the University of British Columbia under the supervision of Dr. Hinch?
DR. MARTINS: Yes.
Q Okay. And you've published dozens of peer-reviewed articles and presented at conferences internationally?
DR. MARTINS: Yes.
Q And much of the research you've done has focused on the issue or matters related to population ecology?
DR. MARTINS: Yes.
Q And most recently you've been studying matters related to population ecology and the aquatic environment?
DR. MARTINS: Yes.
MR. McGOWAN: Those are my questions on his qualifications, Mr. Commissioner. I'd ask that, subject to any questions my friends have, that he be qualified as an expert in population ecology.
THE COMMISSIONER: Very well, thank you, Mr. McGowan.
MR. McGOWAN:
Q Dr. Hinch, I'm going to start by asking you just some basic questions about the background of the report you were asked to complete. I understand you were asked by commission counsel to produce a report on the effects of climate change on the Fraser River sockeye salmon?
DR. HINCH: Correct.
Q And you've completed that report along with Dr. Martins?
DR. HINCH: Yes.
Q Now, the report's titled, "A Review of Potential Climate Change Effects on Survival of Fraser River Sockeye Salmon and an Analysis of Interannual Trends in En Route Loss and Pre-Spawn Mortality"?
DR. HINCH: Correct.
MR. McGOWAN: Okay. I wonder if we could have the front page of that report brought up, please, Mr. Lunn? It's report 9.

Q This is the first page of your report?
DR. HINCH: Yes.
Q Which, including appendices, is 134 pages, approximately?
DR. HINCH: Yes.
Q And that report contains the analysis and the opinions of both you and Dr. Martins; is that correct?
DR. HINCH: Yes.
MR. McGOWAN: Mr. Commissioner, I'm going to take the witness through it, but I wonder if it might be convenient to mark it now as the next exhibit?
THE COMMISSIONER: Very well.
THE REGISTRAR: Exhibit Number 553.

EXHIBIT 553: Report by Dr. Scott Hinch and Dr. Eduardo Martins, titled, " A Review of Potential Climate Change Effects on Survival of Fraser River Sockeye Salmon and an Analysis of Interannual Trends in En Route Loss and Pre-Spawn Mortality"

MR. McGOWAN:
Q And Dr. Hinch, in terms of the structure of this report, I understand the report is really comprised of two separate but related parts?
DR. HINCH: Correct.
Q And the first of those reports was authored primarily by Dr. Martins?
DR. HINCH: Correct.
Q And that portion of the report includes a compilation and an analysis of scientific literature on the document and projected effects of climate-related variables and climate change on Pacific salmon in freshwater across all life stages?
DR. HINCH: Right. Looking for --
Q And marine environment?
DR. HINCH: Right. Looking for associations between known climate variables and survivorship at different life stages.
Q Okay.
DR. HINCH: Using largely peer-reviewed published literature.
Q Okay. And as I said, that was primarily authored by Dr. Martins, but with you overseeing --
DR. HINCH: Yes.

Q -- the project as a whole? And the scope of work for that piece is actually contained within the report as an appendix at page 96; is that right?
DR. HINCH: Right, yeah.
Q Okay. The second part of the report was primarily authored by you?
DR. HINCH: Correct.
Q Okay. And that is a technical report examining trends and en route loss in pre-spawned mortality in the context of environmental variables?
DR. HINCH: Correct.
Q Okay. And you looked at several different sources, including published studies and some data that you obtained to conduct that --
DR. HINCH: Yes.
Q -- draft that part of the report? The draft version of your report was reviewed by several peer reviewers?
DR. HINCH: Yes.
Q Three, in fact?
DR. HINCH: Yes.
Q And you've attached their comments as appendices to your report?
DR. HINCH: Correct.
Q And your responses to them?
DR. HINCH: Correct.
Q Now, before we get into dealing with the specifics of the report and seeking you -- to have you explain your opinions and your analysis, I'm just going to take a few minutes and have you assist the commissioner with some background information about climate change, its relevance to the Fraser River, and the connection of any impact on the Fraser River to what's central to our mandate, and that's Fraser River sockeye.

I'm wondering if you could briefly explain for the commissioner the phenomenon of climate change and how it is impacting on the Fraser River?
DR. HINCH: Okay. Well, there's really three components to climate change the way climatologists would consider it. It's really all about climate variability, in their view. First, is a global issue dealing with greenhouse gas emissions and the increase we've seen in those in the last several decades, and associated with that has been a general increase in temperatures, in

air temperatures in our region of the world. And associated with that, then, would be a general increase in water temperatures.

On top of that, we also have oceanographic atmospheric issues that are going on at the same time. The two notable ones are the Pacific decadal oscillation, which is a phenomenon that persists for 10 to 20 years at a time, switching between what we call regimes of high productivity and low productivity in the ocean, and associated with that are changes in coastal temperatures going from either warm to cool, depending on which state you're in.

Layered on top of that is the other aspect of climate variability, which is what's called ENSO, or El Niño Southern Oscillation, and this is also another naturally occurring phenomenon. It occurs at about a five to seven-year interval. And that brings with it, to our coast, anyway, when it's strong, generally warm water temperatures to the coast.

So you have all three of these phenomenon occurring, contributing to climate variability. And what it's meant in the context of the Fraser over the last 20 years, how these all play together, is a warming of the Fraser River and a warming of the coastal waters in the south and southern British Columbia.

We've seen more frequent El Niño events during this period than we have historically, and actually more frequent switching in the Pacific decadal oscillation as well in recent years. So this extreme variability that we're now seeing has also been predicted to be a consequence of global climate change.

MR. McGOWAN: Mr. Lunn, could you please bring up page 90 of the report?

Q In terms of dealing with the specifics of the impacts on the Fraser River in recent time, I'm wondering if you could, perhaps using this graph to assist you in articulating the point, explain to the commissioner what the trends in the Fraser River have been in terms of temperature?

DR. HINCH: Sure. This figure shows two lines. It's a relationship between average daily temperature in the lower Fraser River and today, from the beginning of June to the end of September. And

what it's showing is that from the early 1950s to 1990, the blue line, you can see what the average daily temperature was. Since that period, or in the more recent period, from the early '90s to the present, we have had, on average, about a degree warming, just under a degree warming throughout that entire time period.

Actually, we've seen even a larger warming period, if we extend back that time period a little earlier, historically, the warming has been even greater. What is not shown on that figure in terms of the warming, because these are averages, is the extremes that we're now seeing, and we have many more extreme warm days in the past 20 years. In fact, 13 of the past 20 years have been the warmest on record.

Q Can you provide to the commission a slide that's taken from one of your other articles that --

DR. HINCH: Yes, that shows that.

Q -- (indiscernible - overlapping speakers) extracted which shows the variability and the high points?

DR. HINCH: Yes.

MR. McGOWAN: Mr. Lunn, that's slide 4, please.

DR. HINCH: It's basically the same figure I just showed you, but I just put on the range of the data.

MR. McGOWAN: If we could zoom in on the coloured -- or on the chart portion of that?

DR. HINCH: So the blue and red lines are the same, the solid blue and solid red. What is added onto this are the dotted lines. The dotted lines reflect an element of statistical variance, and the way to describe it is that each dotted line represents two times the standard deviation around the mean. And so you have a dotted line above the red and a dotted line below the red; a dotted line above the blue, and a dotted line below the blue.

And what this helps illustrate, particularly in the recent 20-year period, is that we have a lot of years, now, where the average daily temperature has exceeded 20 degrees. And for a much longer period. You'll notice that it's a flat -- almost a flat part of that curve between the end of July and the end of August, where the red dotted line extends largely flatly across there. We're now having relatively warm

temperatures much more consistently in the lower Fraser.

The lines on top reflect the run timing groups of fish as they come into the river. And you can see that, now, the warmest temperatures are certainly experienced, historically, as well, but they're experienced by the Early Summers and Summers, and now all run timing groups, however, are experiencing much warmer temperatures.

Q And this is a trend that's been seen over a longer period of time, but if I understand your evidence in recent years, it's become even more pronounced?

DR. HINCH: Well, we have more extreme years, recently. So as I said, 13 out of the past 20 years were record temperatures in the historical context.

Q Is there a general consensus in the scientific community as to whether the warming trends in the Fraser are anticipated to continue into the future?

DR. HINCH: Yes, all the scientific literature and the modelling suggest the warming will continue. The debate is over the rate of warming. Conservative models predict over the next 60 to 80 years a two-degree additional warming; however, less conservative models predict four or more -- higher degrees warming.

Q Over that same 60 to 80-year period?

DR. HINCH: Yes. And I'm just showing you summer temperatures here. This pertains primarily to the adult migration phase. Not shown here would be the warming that's occurred in the winter and spring, which is actually at a higher rate and it's expected -- all models suggest that the warming in the winter and spring will be at a greater rate than what we're going to see in the summer for our part of the world.

Q And when we come to Dr. Martin's piece, we'll talk about the climate-related variables and the potential for them to impact on other life stages of the --

DR. HINCH: Right.

Q -- in addition to the returning adult; is that right?

DR. HINCH: That's correct.

Q Now, in terms of keeping in mind the warming temperatures, I wondering if you can briefly address for the commissioner the significance of

temperature to sockeye salmon?
DR. HINCH: Okay. Well, temperature has been coined by some very famous colleagues as the master biological factor for fish. It controls everything from metabolism to physiology to behaviour to feeding, and there's really well-known relationships for many species about how temperature affects those processes.

In sockeye salmon, in particular with the adults that I'm focusing on with this figure, you can think of mortality and survivorship as being related to two general processes; things that kill you quickly, or acute, and things that will kill you slowly, or chronic.

The acute processes involved in mortality usually are related to how your metabolism or your heart performance ceases. And those things happen quickly at certain temperatures. The more chronically-related effects have to do with diseases and energy exhaustion, which will take some time to take its toll on individuals, depending on what the water temperature is. In both cases, they're leading potentially to the same fate, it just may be the time scale over which the ultimate fate is determined.

And those processes would be consistent for all free-swimming life stages, it's just that what we're seeing now with the adults is that we're seeing a lot more of the acute issues occurring.

Q Is there an optimum temperature, an optimum temperature range for sockeye?

DR. HINCH: All fish have an optimum temperature, and if you go to that one figure, the first figure, I can explain the theory behind that.

MR. McGOWAN: Could we have slide 1, please, Mr. Lunn?

Q This is a figure which -- a process or a figure which you've described in a number of your articles --

DR. HINCH: Yes.

Q -- and we've extracted it so we can display it on the large screen here?

DR. HINCH: Without the figure it's much harder to describe verbally. On the left-hand axis we're looking at the amount of oxygen that a fish needs for a particular activity. On the bottom axis we're looking at temperature. The green line shows the amount of oxygen that's needed to

sustain life. So this is the basic elements for -- required for life. And temperature plays a strong role in that. The higher temperatures you need more oxygen to sustain your existence.

The blue line shows how much oxygen you need to swim maximally, or be as active as you can possibly be. What happens with the maximum oxygen requirement is that it has a dome-shaped relationship. So it starts to decline at higher temperatures. The decline has to do with the way proteins breakdown and enzymes breakdown in higher temperatures.

So where that blue line and that red line cross, the fish has no ability to take oxygen and use it any longer and the fish is dead. The difference between the blue and red line we call the scope for metabolism, and there's a temperature where it's optimum so they can be most active, and there's a temperature where it's critical and they're dead. So the "T opt" reflects where their scope is widest, and so they have the best ability to survive, and there's a point where they have no ability to utilize oxygen any further and they cannot swim and they cannot feed. And we call that "Zero Scope" where the fish are dead.

This relationship has been established for many fish species, many life stages; we've just spent a lot of time working on it for the adult life stage of sockeye, but certainly this pertains to all life stages that are free-swimming in fish, because fish are what used to be called "cold-blooded". In scientific terms, they're heterotherms, and as a result, their body temperature reflects the water temperature and this is the way water temperature affects their bodies.

Q Okay. So the bottom line, which is the green line, relates to the amount of oxygen that's being used to deal with just regular survival?

DR. HINCH: Just sitting still in the water and breathing.

Q Okay. And anything above and beyond that and the capacity to conduct any activity above and beyond that is reflected by the top line, which is the blue line?

DR. HINCH: Well, anything above that is above the

green, the maximum ability -- their maximum activity would be the blue line.

Q All right. And when the blue line meets the green line, the fish has no ability to take any activity and will die?

DR. HINCH: Correct.

Q Now, short of that, at a temperature somewhere short of that, the place where the blue and the green line meet, is there still the potential for temperature to have adverse effects on the sockeye?

DR. HINCH: Yes. As the blue line declines and the green line increases, swimming becomes very stressful. So you have the secondary effects that can contribute to the fate of the fish, which would include the build-up of lethal concentrations of stress metabolites in the blood. As well, they can't swim as efficiently, and so if they need to swim through fast-moving waters at high temperatures, they'll have the inability to do so.

And at the same time that this is happening, you've got those chronic processes occurring that I mentioned earlier, where you have energy exhaustion happening and you have -- which pertains to the adults in particular, and you have disease, if it's present, also ramping up, because disease is temperature mediated as well. Energy use is mediated by temperature, and it should be pointed out that in the adult phase these fish are not feeding. They've stopped feeding before they've entered freshwater, so on the homeward migration they are starving and utilizing energy reserves the entire way.

Q Now, I take it there's variability of optimum and critical temperatures between fish species; is that correct?

DR. HINCH: Absolutely.

Q And is there also variability within sockeye between different groups?

DR. HINCH: Yes. In the last 10 years we've spent a lot of time looking at that and we're starting to identify differences among populations of salmon, showing what we believe to be local adaptation to river migration conditions.

Q Can you give the commissioner a general sense of what temperature range we're looking at for

sockeye for optimal and critical levels?
DR. HINCH: Sure. Well, I think the next slide, which is actually in one of the documents that was put forward as evidence, highlights an example of this. This is right out of one of my papers and it shows for three different populations of salmon in this case; two are sockeye, one is Coho.
On the left-hand side you're looking at the scope. The metabolic scope was the difference between that blue line and the green line. So the difference between those two lines shows a parabolic function. And so these are lines derived from data that shows for a Summer-run stock, which is Gates Creek sockeye, the scope, for a Late-run stock, Weaver Creek sockeye, the scope, and for a very Late-run group of fish, the Chehalis Coho, the scope, and you can see that there is an optimum temperature for each one. That's where the scope is greatest.
And so the scope is greatest for the Summer-run fish at warmer temperatures than for the Late-run fish, and the temperature is optimum for the Fall-run fish at a much cooler level.
Going along with this optimum temperature issue is that the line does come down and cross zero, where you have no scope, where the fish are dead. And so the temperature that is thermally critical is indicated by "T crit" and you can see the T crit also varies by each stock, with Summer-run fish having higher critical temperatures than Late-run fish who have higher critical temperatures than Fall-run fish.
Q Okay.
DR. HINCH: But the temperature, you asked me about what temperatures are the issues. You can see there the actual temperature critical for Late-run fish is just above 20 degrees, and the critical for this particular Summer-run group is about 24 degrees.
Q And the optimum temperature for sockeye is somewhere in the neighbourhood of, what it looks it from this chart, 15 degrees, in that range?
DR. HINCH: Right. At the species level, it would be between, you know, 14 -- 13, 14, 15 degrees but, again, when you start looking at the population level it gets more specific.
Q Thank you, Dr. Hinch. With that background in

mind, I'm going to turn to the first portion of the report, and Dr. Martins, I'm going to direct my questions on this section of the report primarily to you, though Dr. Hinch, as the overseeing and lead author, you should feel free, of course, to weigh in if there's anything significant that you want to deal with.

MR. McGOWAN: And perhaps before we leave this, I've put three slides to the witness, Mr. Commissioner, and I think perhaps they should all be marked as exhibits. I referred to them all as slide 1, slide 2 -- I think the first one we showed the witness I referred to as slide 4, and that was the one with the coloured arches dealing with temperature. I wonder if that could be the next exhibit?

THE REGISTRAR: 554.

EXHIBIT 554: Fraser River Peak Summer Temperatures slide

MR. McGOWAN: Thank you. The next slide I referred to as slide 1.

THE REGISTRAR: 555.

EXHIBIT 555: Metabolic Scope and Temperature slide

MR. McGOWAN: And then the slide that was just on the screen, I'd referred to it as slide 2, the Gates and Weaver Creek stocks on the left, if that could be the next exhibit?

THE REGISTRAR: 556.

EXHIBIT 556: Metabolic Scope Temperature Profiles for 3 Fraser Salmon Stocks slide

MR. McGOWAN: Thank you.

Q Dr. Martins, I'm going to talk to you about your first part of the report, and that included literature review --

DR. MARTINS: Yeah.

Q -- is that correct?

DR. MARTINS: Correct.

Q And the information that you took to conduct your analysis all came from that literature review; is that right?

DR. MARTINS: Correct, yeah.
Q Specifically, you searched the scientific literature and synthesized the current state of knowledge on the relation between climate-related variables and sockeye survival?
DR. MARTINS: Yep, correct.
Q Okay. And that literature review is conducted with an eye to assessing the likelihood that these climate-related variables interacted or were related to sockeye survival at different life stages?
DR. MARTINS: Yes.
Q Okay. When you initially did your literature search, how many articles did you identify?
DR. MARTINS: We identified about 1,800 articles.
Q Okay. And did you go through a process of whittling those down to find the key articles that were relevant to your analysis?
DR. MARTINS: Yes.
Q Explain, please, for the commissioner, that process.
DR. MARTINS: Yeah, that process involved removing duplicate articles that were found in the different tools we used to find the articles. We also removed some articles that weren't relevant for our purposes, and this is just because of the way the search engines look for articles. Sometimes they give us some articles that are not directly related to what we are searching for.
There was also some conference abstracts that we didn't take into account just because they don't provide enough detail to -- for us to conduct our analysis. Yeah, and as far as I can remember, these were all the criteria used.
Q And after applying those criteria to limit the list, how many articles were you left with?
DR. MARTINS: A hundred fourteen.
Q Okay. And what did you do with those 114 articles?
DR. MARTINS: We just used these articles to provide the general sense of the trends in the study of climate-related variables in sockeye, so trends like temporal trends in how we have been conducting these sorts of studies, the life stages that have been studied so far, what the climate-related variables have been used, to name a few.
Q Okay. Now, you ultimately conducted a qualitative

analysis --
DR. MARTINS: Yes.
Q -- of the different life stages and the likelihood that climate-related variables --
DR. MARTINS: Yes.
Q -- impacted on sockeye survival?
DR. MARTINS: Yep.
Q And you didn't use all 114 articles for that; am I right?
DR. MARTINS: No.
Q Okay. How many articles did you use for that section of the analysis?
DR. MARTINS: We used 28 articles that dealt directly with survival.
Q Okay. And from the 114, how did you select the 28 articles?
DR. MARTINS: The ones that were dealing with survival.
Q Okay. So you took from the 114 and isolated each of the articles that dealt with sockeye survival --
DR. MARTINS: Yeah.
Q -- and used those as the basis upon which you conducted your analysis?
DR. MARTINS: Yes.
DR. HINCH: And it was Fraser sockeye survival.
Q Fraser sockeye survival.
DR. HINCH: So, I mean, there were more articles that dealt with other groups of sockeye, but we were asked to focus largely on Fraser and so that's what we did.
Q And the qualitative analysis that you conducted resulted in you ascribing a likelihood --
DR. MARTINS: Yeah.
Q -- that climate-related variables impacted on Fraser sockeye survival at different life stages --
DR. MARTINS: Yes.
Q -- is that right?
DR. MARTINS: Yeah.
MR. McGOWAN: I wonder if we could bring up pages 28 and 29 of the report; is that possible? Or at least the bottom part of 28 and the top part of 29, where we set out the -- starting with "very likely" and finishing with "unlikely"? Starting at the top, with "very likely" sub point "i". Right. And I think that covers it.
Q Maybe you can walk the commissioner through what

the method was for assigning --
DR. MARTINS: Yeah.
Q -- the likelihood to the various life stages --
DR. MARTINS: Okay.
Q -- and how you went about that?
DR. MARTINS: So we defined five rates -- five -- four rates of likelihood, very likely, likely, possible, and unlikely. We would define something as very likely if we could find a recent trend in survival related to a climate-related variable in any of the papers. So that would be our first criteria, to define something as very likely, but none of the papers we examined had the recent trend.

So the next step was to look if these papers had found a significant relationship between surviving a climate-related variable, for example, temperature. And based on our experience with the field, we thought that at least around four papers would be considered enough evidence for something that is very likely to have been -- to have occurred, so we defined a cut-off of four papers, defined a significant relationship between survival and climate-related variable to define these changes -- or specific changes very likely.

And the same -- an additional criteria for this was that these relationships would have to be corroborated with laboratory studies, specifically when these studies were providing some evidence of the mechanisms by which climate effects survival.

The next criteria was "likely" and similar to the "very likely", but the field studies had not been corroborated yet by laboratory studies.

Then we had the "possible" rate, which is based on some limited amount of information from field studies up to three papers providing a significant relationship between survival and a climate-related variable, which could be or not corroborated by laboratory studies. Or, in the absence of field studies, if they had provided some evidence in the laboratory for relationship between climate-related variables and survival.

And the final rate was "unlikely". When some studies have tried to -- have looked into if there was a relationship between survival and climate-related variable, but their data had not provided evidence either in the lab or the field for that

relationship.
Q Okay. Let me see if I can summarize what you've told us and make sure that I understand it.
The first criteria was "very likely" and that would indicate a very likely relationship between a climate-related variable and survival of Fraser sockeye?
DR. MARTINS: Sorry, it's very likely that there has been a trend in survival due to climate change.
Q Okay. Now, the first thing you looked for was a recent trend, and you didn't find any of those in the articles --
DR. MARTINS: Sorry, can you say --
Q The first possible way you might have ascribe the qualitative assessment of "very likely" would be if you'd identified a recent trend --
DR. MARTINS: Yeah.
Q -- in the literature --
DR. MARTINS: Yeah.
Q -- and you did not?
DR. MARTINS: No, because none of the papers had reported a trend.
Q Okay. The "very likely" qualification could also be assigned if there was at least four articles which established the relationship and that relationship was corroborated by laboratory studies?
DR. MARTINS: Yes.
Q Okay. The "likely" criteria would be assigned if there was at least four field studies that identified the relationship but there was no laboratory --
DR. MARTINS: Yep.
Q -- information? The possible criteria would be ascribed if you found a relationship in one to three studies?
DR. MARTINS: Yeah.
Q With or without confirmation in the lab?
DR. MARTINS: Yeah.
Q And the "unlikely" qualification would be given if there was no relationship found in any of the field or laboratory studies?
DR. MARTINS: Yes.
Q Okay. So you took each of the life stages and identified articles which focused on that life stage and looked for the -- whether or not you could identify a relation -- or whether the

articles identified that relationship?
DR. MARTINS: Yes.
Q Okay. And this analysis was based entirely on -- or only on those 28 articles that you --
DR. MARTINS: Yes.
Q -- found? Now, is 28 articles, is that -- I'm not, perhaps, as familiar as some with scientific literature, but we're dealing with Fraser sockeye and you've identified 28 articles.
DR. MARTINS: Yeah.
Q Is that considered a large number of articles on a particular topic?
DR. MARTINS: Yeah. In terms of what we know about, that has been studied about survival, yes, it's a relatively large amount. There are not as many papers in other river systems dealing directly -- dealing just with survival at that level.
Q Dr. Hinch, in comparison with other river systems, how -- what is this 28 papers that have been identified tell you about the extent to which the survival of Fraser of sockeye has been studied compared to sockeye and other river systems or other salmon?
DR. HINCH: Compared to across all life stages in other salmon species, this is one of the larger datasets of papers that you're going to find. There's been a fair bit of research effort given to Fraser sockeye. But having said that, it's still a small amount of research effort in the grand scheme of fish biology, but in terms of salmon it's a relatively large dataset.
Q Okay. Dr. Martins, you've used sort of four as the baseline for getting to "likely" or "very likely".
DR. MARTINS: Yeah.
Q Did you consider what the impact on your results would have been if you'd changed that criteria to either three or five or some other number?
DR. MARTINS: Yeah, we could do that. What we did was to -- we based that on the life stages we know. It's generally acknowledged that climate change has had an effect on sockeye, which are the smolts and mainly the returning adults in the river. And for these life stages we could find at least four papers that had shown the relationship, a significant relationship, between, say, temperature and survival, so that was our -- the

life stages we were basing for describing these two categories.
Q Okay. Now, we keep talking about climate-related variables. Is one of the climate-related variables temperature?
DR. MARTINS: Temperature is a climatic variable.
Q Okay. And is --
DR. MARTINS: And a climate-related variable would be variables that are affected by climate variables.
Q Okay. And in terms of the studies that you had, what was the climate-related variable that was most often studied?
DR. MARTINS: Temperature.
Q Now, I see that you've got a greater than or likely greater than equal to four. To get to the likely stage, if something had been studied 15 times --
DR. MARTINS: Yeah.
Q -- and a relationship identified in five of those studies --
DR. MARTINS: Yeah.
Q -- would you qualify -- would you determine that the relationship is likely?
DR. MARTINS: And the other 10 papers would identify as not likely, is that --
Q Yes.
DR. MARTINS: No. Well, one thing we have to keep in mind is the consistency between the results. So we are looking at -- we didn't mention here, because most of the papers were consistent on there, so if there was a positive relationship between surviving temperature and negative relationship, they are consistent among all the studies.
Q So was this -
DR. MARTINS: Where there --
Q Sorry, go ahead.
DR. MARTINS: Where there wasn't consistency, we could understand why. That was, for example, when we had difference between stocks, which stock with Scott we will go into the details later.
Q Right. So consistency was another criteria you apply, but it's not articulated in the (indiscernible - overlapping speakers) --
DR. MARTINS: Yeah, it's not articulated, because there's not inconsistence in the -- that would affect any of these relationships.

Q Okay. And I see that we've got the one to three studies is - gets you to "possibly" --
DR. MARTINS: Yeah.
Q -- for a relationship. If something had only been studied, one of the life stages had only been studied three times, regardless of the strength of the relationship --
DR. MARTINS: Yeah.
Q -- that was identified in those three studies, it could never be rated more than "possibly" --
DR. MARTINS: Yeah.
Q -- according to your criteria?
DR. MARTINS: Yeah.
Q Okay. So I think we understand the criteria. Now, you took these criteria and assessed them against each of the life stages; is that correct?
DR. MARTINS: Mm-hmm. Yeah.
Q You've set the results of that analysis out in a chart at page 78 and 79; is that correct?
DR. MARTINS: Yes.
MR. McGOWAN: I wonder if we could bring that chart up, please? Is it possible we can get the whole -- see the whole chart at once, or should we... Perhaps we can just do one page at a time so we can all see, and I'll ask you to move down.
And Mr. Commissioner, if you'd prefer, you have a hard copy of the report in front of you as well.
Q Now, this chart sets out the results that you identified; is that correct, Dr. Martin?
DR. MARTINS: Yes.
Q Okay. And in addition, in the body of the report, in addition to identifying the likelihood of a relationship, where the relationship exists or may exist, you also offered an opinion as to potential mechanisms; is that right?
DR. MARTINS: Yes.
Q Okay. Explanations for the relationship?
DR. MARTINS: Yeah, what they're -- where we an ascribe these mechanisms we did.
Q Okay. So if we look at this chart as set out, the left-hand column talks about the life stage that you are analyzing?
DR. MARTINS: Yes.
Q The second column, under "Publication" identifies the articles that you identified with respect to that life stage and considered in your analysis?

DR. MARTINS: Yes.
Q And the climate-related variable that was considered is identified in the third column?
DR. MARTINS: Yes.
Q Okay. And then if we go to -- if we move over, you provide some information about the information that was found. What does "variable range" talk about?
DR. MARTINS: Oh, the range of the variables. For example, temperature in this study was assessed between, let's say for the first study here, Murray & McPhail, they assessed the effect of temperature in the range of two to 14 degrees.
Q Okay. And then the relationship with survival, you provide some information there about whether or not you'd identified the relationship in the --
DR. MARTINS: Yeah.
Q -- that column?
DR. MARTINS: Yes.
Q And the type of study you identify whether it was a field or laboratory study?
DR. MARTINS: Yes.
Q And then you've told us already you didn't identify any recent trends; is that right?
DR. MARTINS: Yes.
Q And then finally, the last column is where you really set out your opinion as to what you identified in your analysis, whether it's possible, likely, or very likely, et cetera?
DR. MARTINS: Yes.
Q Okay. Let's start with the egg and alevin stage. Explain to the commissioner, please, what you concluded with respect to that life stage.
DR. MARTINS: Yes, in this life stage we found laboratory studies that evaluated survival across the range of temperature, usually between two and 16 degrees. And in the case of eggs the authors found there is an optimal relationship. That means that survival is the highest at a temperature, in this case, eight degrees, and survivor decreases above eight degrees and below eight degrees.

In the case of alevins, they didn't find any relationship, so survival is basically constant across this wide range of temperatures.
Q So you found no relationship at the alevin stage, but at the egg stage you actually found the

possibility that climate-related variables were increasing survival?
DR. MARTINS: Yeah, that's in the likely -- I mean, no, the first thing I'm describing is just a relationship that the studies had found.
Q Yes.
DR. MARTINS: So they were saying that there's an optimum temperature --
Q Yes.
DR. MARTINS: -- for survival and below and above these temperatures survival decreases.
Q Right.
DR. MARTINS: Okay? And based on that, and so knowing that typical temperature during the incubation time for sockeye is about five degrees.
Q Mm-hmm.
DR. MARTINS: We ascribe that there's a -- and that climate has been warming recently ascribe that possibly -- that survival has possibly increased in the recent decades due to that. But there's one possible caveat here, is that we're -- and that's why we just say "possible" is that we are extrapolating our result from the lab to what might be happening in the wild. So in the wild, temperatures are not constant like they were held in the studies here. In the wild, temperatures are fluctuating throughout the incubation.
DR. HINCH: I can add to that, that thinking about in the free-swimming life stages there's this optimum temperature and with the adults we are well beyond the optimum. If you are within the optimum range and you modestly increase temperatures, you actually can push you into still a favourable optimum, or you can be below optimum and be pushed into a slightly better optimum.
So it's our opinion that with the limited lab work it's possible with a small increase in temperatures that we would have witnessed in the streams that you could have actually had a potential increase in survivorship. But again, the limited number of studies and the fact that they're all lab-based means that it's a "possible".
Q Okay. Thank you. Let's move, then, to the fry in lakes stage -- life stage of the sockeye.
DR. MARTINS: Yes?
Q You considered five articles at that stage?

DR. MARTINS: Yes.
Q And what did you conclude about the possibility of a relationship between climate-related variables and the fry stage?
DR. MARTINS: What these articles show is that at a reasonable range of temperature experienced by sockeye in the wild, the survival decrease as temperature increase. So the problem is that we don't think temperature affects the survival directly, because the fish in lakes, they can go to deep portions of the lake and escape from lethal temperatures that they might encounter on the surface. So some of these studies were showing that there was a relationship between increased predation mortality and temperature. So the higher the temperature, the higher the predation mortality that sockeye was experiencing in the lab.

So given the limited amount of information we had from field study, we ascribed a possibility that survival in recent decades has possibly decreased because of the increase in temperatures in the lakes.
Q Okay. And the mechanism by which the survival might be --
DR. MARTINS: Mm-hmm.
Q -- is possibly decreased, in your opinion, is related to increased predation?
DR. MARTINS: It could be increased predation. It could also be change in the quantity of food and the quality of food, but we don't have that information.
Q Okay. Let's move, then, the smolt and postsmolt stages. You have six articles identified there?
DR. MARTINS: Yes.
Q Okay. So there was six articles dealing with climate-related variables and their relationship to survival of the smolt --
DR. MARTINS: Yeah.
Q -- and postsmolt stage?
DR. MARTINS: Yes.
Q Okay. And you've identified a "likely" relationship there?
DR. MARTINS: Yes.
Q Explain that to the commission, please.
DR. MARTINS: All these studies dealing with sockeye from the Fraser River has shown there's a negative

relationship in the temperature that fish encounter when they enter the ocean and their survival. Some mechanisms that have been proposed for this is that when temperatures along the coast of British Columbia are warm, there's a decreasing productivity of food for the sockeye, and there's also the possibility that predation mortality is increased. There has been some observations of salt (phonetic) in predators moving up the coast when temperatures are warm. And there's also the possibility that resident fish might increase the predation rates on sockeye to -- to offset the increased metabolic rates that they have with warm waters.

So there's zero relatively large amount of evidence from field studies here and then we ascribe the possibility of likelihood that survival has likely decreased due to recent warming.

Q So of the six articles you looked at, five of them, it looks like, identified a relationship?

DR. MARTINS: Yes.

Q Okay. And you've explained some of the mechanisms by which this relationship might come about?

DR. MARTINS: This might come due to decrease in food -- food production when the coast is warm, and the increased predation rates when it's warm as well.

Q Okay. Did you give any thought, or can you offer an opinion, on the relationship between these mechanisms and the difference in run sizes in 2009 and 2010 --

DR. MARTINS: Yes.

Q -- with respect to water temperatures?

DR. MARTINS: It was based on a report that was going to come to the Cohen Commission from another project that shows some very unusual conditions close to the Queen Charlotte Islands in 2007, when the fish from 2009 returns were going to the sea. When they got to this region they encounter really warm temperatures and low food production.

Q All right. So you made reference to another report that you've had some --

DR. MARTINS: Yeah.

Q -- information about through the process that the commission has and the interaction with other scientists; is that right?

DR. MARTINS: Yes.

Q And as a result of some information you got from that, you offered an opinion in this report --
DR. MARTINS: Yes.
Q -- about the relationship of water temperature -- the potential relationship between water temperature and the differences in run size in 2009 and 2010?
DR. MARTINS: Yes.
Q Okay. Dr. Hinch, do you have anything to add to that?
DR. HINCH: Yes, I guess to somewhat reiterate and expand, you know, there was information provided that suggests that in 2007, when the 2009 fish would have been heading into the early marine phase of their life, that they were encountering, in different locales along the coast, very poor growing conditions, which is consistent, then, with the poor returns that have been suggested by these other papers.

Similarly, in 2010, the fish that left, they would have gone out in 2008, and they would have encountered, given some of the results we've seen, the environmental data, that it was much more favourable growing conditions and survival conditions, again consistent with these papers suggesting a link between climate variables and the survivorship in that stage of their life.
Q All right. So that piece of information fits, in your view, nicely with the analysis that you're conducting here?
DR. HINCH: With these published -- it does fit with these previously published studies, yes.
MR. McGOWAN: Mr. Commissioner, the project that's being referred to by the witness is, just for your information, is Project 4.
Q So the next life stage that you considered, Dr. Martins, was immature sockeye in the ocean?
DR. MARTINS: Yes.
Q And you again analyzed the possibility of a relationship between temperature or other climate-related variables and survival?
DR. MARTINS: Yes.
Q And you've studied, or you looked at -- you identified only two papers on this life stage; is that right?
DR. MARTINS: Yes.
Q So the highest possible qualitative assessment

that you could ascribe is "possible" is that right?
DR. MARTINS: Yes.
Q With two papers, you could never identify a "likely" --
DR. MARTINS: No.
Q -- or "very likely" relationship, according to your criteria?
DR. MARTINS: No.
Q Okay. Explain to the commissioner what you concluded and discuss possible mechanisms.
DR. MARTINS: Of these two papers, just one of them dealt with Fraser River sockeye, and the relationship that was found was a negative relationship between temperature that the fish was experiencing their last few months in the open ocean and survival. And we don't know what the mechanisms could be. It could be the relationship between food and temperature for these fish. And so based on the only evidence we had, we just described it likely here that survival has possibly decreased due to recent warming.
DR. HINCH: I think it's also worth mentioning, if you look at the entire table in context, that this stage of their life is the most poorly understood, and we've known this for a long time, that there's just not a lot of research effort put into studying this life stage and it's certainly a major data gap and a major understanding gap.
Q That's helpful, thank you. Just so that we understand what portion of the life stage you're talking about here, Dr. Martins, when you say "immature in the ocean", what period of the life stage are you talking about? Is it the entire time in the ocean, or is it a specific period you were looking at?
DR. MARTINS: We tried to look for the entire time they are in the open ocean, but the only paper we could find was just relating to a specific time at the end of this life in the open ocean, the last few months in the open ocean.
Q The last few months prior to re-entry?
DR. MARTINS: Yeah.
DR. HINCH: And the way --
DR. MARTINS: Prior to returning along the coast.
DR. HINCH: The way these studies often take place is they're retrospective and they're looking at

adults that return and then try to ascribe survivorship through various means to what would have happened earlier in their life six to eight or earlier months before that.

Q Okay. Thank you. Now, there's two more life stages left, Dr. Martins. I'm going to ask you about your conclusions, but I'm going to save discussion of the mechanisms for Dr. Hinch --

DR. MARTINS: Sure.

Q -- because his portion of the paper deals in a little more details with these two life stages.

DR. MARTINS: Yes.

Q Dealing with returning adults, that's the area where you found the highest number of studies?

DR. MARTINS: Yes.

Q Okay. Tell the commissioner what you concluded about the likelihood of a relationship between climate-related variables and survivor at that life stage.

DR. MARTINS: Yeah. So all these studies have shown negative relationship between survival of sockeye when they're migrating upstream. And the conclusions we got from -- based on the recent ones that survival has very likely decreased, but not in all stocks. As we'll see, there is some difference among stocks.

Q I wonder if you could just identify the differences among stocks that you identified, please?

DR. MARTINS: One of the stocks was the Chilko stock. They seemed very resistant to warm temperatures.

Q And when does the Chilko stock conduct its upward migration?

DR. MARTINS: During the mid summer.

Q Okay. Let me take you, then, finally, to the spawner stage.

DR. MARTINS: Yeah.

Q You only found three studies at that stage?

DR. MARTINS: Yes.

Q And what did you find with respect to the possibility of a relationship between climate variables and survival at the spawning stage?

DR. MARTINS: For some stocks there's a negative relationship between the temperature they encounter during the upstream migration and on spawning grounds and survival, but the relationship's not consistent among the stocks in

the case of the Fraser River. So some stocks are not affect -- don't seem to be affected by the warm temperatures.

Q Okay. Now, we're talking about --

DR. HINCH: I should also add, though, about the Gilhousen paper, the very first one. It actually considers all the stocks. So although we're looking at three papers -- only three papers, and again, not a lot of research, interestingly, has been done on this life stage, that particular first paper, though, did look at all Fraser stocks, so it's quite a compilation up to that period.

Q Okay. Thank you. Now, when we're talking about survival at the spawning stage, of course, ultimately, none of the sockeye survive at the spawning stage.

DR. MARTINS: Yes.

Q So when you talk about survival, what do you mean at this level?

DR. MARTINS: We mean survival before they spawn. So it's pre-spawn survival.

Q Okay. So they're able to survive to the point where they deposit the eggs?

DR. MARTINS: Yes.

Q Okay. Just before we leave this chart, Dr. Hinch, I'm looking at the returning adult section of the chart and I'm looking specifically at the variable temperature ranges that were considered.

DR. HINCH: Yes.

Q In the first paper there, Servizi & Jensen, 1977, they're dealing with a temperature range of 18 all the way up to 30 degrees. I'm wondering if you can assist the commissioner with how that fits with what you've told us about critical temperatures?

DR. HINCH: Yes. It's quite interesting. No other study, since, has been able to do laboratory studies with adults, adult sockeye, up to those temperatures. We've tried, and it's just not possible to keep them alive. And it turns out my early colleagues were certainly using particular drugs to ward off diseases and other mechanisms to enhance the survivorship of their experiments. They were interested particularly in looking at other relationships, not the ones that we're necessarily describing today. So it was possible

for the -- it is possible to keep fish alive at really high temperatures if the water is pathogen free or the fish are clear of diseases and other potential infections. So certainly that's an anomalous study in regards to the way all the other studies have taken place since then.

Q Okay. So what you've told us about critical temperatures and real world conditions continues to hold, despite that study?

DR. HINCH: Yes. I mean, all the studies that have been done since then are using, you know, real water from the migration and fish that aren't chemically treated in any fashion.

MR. McGOWAN: Thank you, Dr. Martins, for your explanation of that portion of the report. I'm going to turn, now, Mr. Commissioner, to the second portion of the report. I don't know if it's your preference to take a short break now, or if you'd like me to carry on for another 20 minutes or so?

THE COMMISSIONER: Sure.

MR. McGOWAN: Okay, I'll carry on, thank you.

Q Dr. Hinch, you were the primary author on the second portion of the report, which I understand deals with trends in en route loss of returning adults and with pre-spawn mortality?

DR. HINCH: Yes.

Q And to conduct this portion of the report, your analysis in this portion of the report, you conducted a literature review -- or you reviewed literature and you also considered -- conducted an examination of existing data?

DR. HINCH: Yes.

Q Okay. And if I understand the process you went through, you looked at three sources of information. The first was telemetry studies?

DR. HINCH: Correct.

Q The second was laboratory studies?

DR. HINCH: Yes.

Q And the third was data about en route loss and pre-spawn mortality that you were provided either by the Pacific Salmon Commission or the Department of Fisheries and Oceans?

DR. HINCH: Yes.

Q Okay. Let's start by talking about the telemetry studies. Is that a sensible --

DR. HINCH: Yes.

Q -- way to begin?
DR. HINCH: Sure.
Q Okay. Explain to the commissioner what a telemetry study is, please.
DR. HINCH: Sure. So telemetry is a means of tracking individual fish by inserting different sorts of devices either into them or onto them. In the case of adult salmon, we generally - "we"; I do a lot of this, but my colleagues do as well - transmitters are inserted down the throat, into the stomach. It's a rather rapid procedure, it occurs in a few seconds, the fish are not feeding, and the tag is permanently embedded into the fish and it really can't come out after that point because the stomach is shrinking and shrinks around the transmitter. So it's an effective tool for being able to track individuals.

And then once the transmitter is inserted, in some studies, and certainly several that I've been involved with, we may be taking blood samples associated with that, or biopsy samples, so that we can get an indication of the wellbeing, the condition, the health of the individual at the time of capture and release.

Associated with this particular procedure, then, would also be a system, a basin-wide system of listening devices that would be able to pick up the movements of these fish. There have been several of these in place since the early 2000s. A noted one has been run by LGL Limited in the Fraser basin. This is a radio receiver system, which allows a radio transmitter to be detected at different points along the adult migration towards spawning grounds.

Another system that is in place and parallel is called an acoustic receiver system. And this allows fish carrying acoustic transmitters to be detected. One of these systems, an example of that, is the POST system that is positioned along the B.C. coast, the Pacific Ocean Shelf Tracking Project system that is managed by the Vancouver Aquarium. And then, in conjunction with additional receivers that groups would put in the fresh -- in freshwater, you could have an acoustic listening array in place at the same time as these radio receiver arrays were in place.

And so over the better part of a decade,

then, fish were being captured, tagged, and tracked through various portions of their migrations across a range of stocks, and I would estimate several thousand individual adults were inserted and tracked during this time period. It's worth mentioning that these telemetry systems are now largely being unfunded and a lot of this information may not be collected again.

Q So the telemetry information allows you to collect information about the whereabouts of the fish --

DR. HINCH: Yes.

Q -- physically? Does it also, in some circumstances, provide information about the depth that the fish is at?

DR. HINCH: It depends. Some of them do. But it has to do with the transmitter that's used. So the inexpensive, frequently used transmitters, just tell you the location as it passes by a remote receiving station, and the time and that sort of thing.

More sophisticated transmitters can also tell you information on the temperature of the fish, the depth of the fish, and so if you were individually following it, you could get all of that information.

Q And are you able to take the information about the whereabouts of the fish and put it together with information about other factors, such as temperature?

DR. HINCH: Yes. So there is a large temperature monitoring program that DFO runs in the Fraser River, called the Environmental Watch Program, and they've been in operation since the mid 1990s, and they've been monitoring and modelling the water temperatures throughout the Fraser basin during this time period and it's been very useful for being able to obtain both real time and historical information on temperature that fish would have encountered based on their known positions from telemetry data.

Q Okay. And what do the telemetry studies tell us about sockeye and the relationship to their return migration to river temperatures?

DR. HINCH: Right. So there's been several done, and the best compilation that was done was recently published. Actually, the lead author was Eduardo. And bringing together 1,000 or more individual

fish over a several year period. What it showed us was that there was a strong relationship between migration temperature and survivorship to reach spawning locales, and temperature really got to be an issue once we crossed the threshold of about 18 degrees. Mortality started to occur in the river at different locales.

When temperatures got to 19 to 20 degrees, we really start to see significant changes in survivorship, declining survivorship, in most stocks. There were some stocks, however, that were more resistant to that, and you've already brought up the one issue of the Chilko sockeye, which certainly resisted the higher temperatures and were able to survive much better, but other stocks survived really poorly at these high temperatures. In particular, we were identifying several of the Late-run stocks that did that.

Q Okay. Now, you took that information that you got from the telemetry studies and you then looked at laboratory studies.

DR. HINCH: Right.

Q And how did the information from the laboratory studies --

DR. HINCH: So those figures that I presented earlier, talking about scope, metabolic scope, are the laboratory studies that were looking at different populations' abilities to cope with higher temperatures.

Q Right.

DR. HINCH: And what you found was that the populations that had an ability to cope with higher temperatures in the lab were also those ones that seemed to cope better in the telemetry studies. So there was support on a mechanistic basis, a physiological basis, for why some of these patterns were likely observed in the telemetry data.

Q So you're finding a consistency between the laboratory studies --

DR. HINCH: Yes.

Q -- and what you've learned from the telemetry studies?

DR. HINCH: Correct.

Q Okay. And the third thing that you looked at was data that was provided to you; is that right?

DR. HINCH: Yes, from management agencies. And the

data that I was particularly interested in looking at was what's called en route loss. And since the early -- sorry, since 1977, there's been a facility near the town of Mission, the hydroacoustics facility, that estimates the numbers of fish that are migrating upriver, and the Pacific Salmon Commission runs that facility.

The numbers of fish that are migrating upriver are estimated there. They've used scale analysis and DNA ID in recent years to ascribe stock identification to the portions of fish that are passing through there. Information is then collected at the end of the season on how many fish made it to the spawning grounds. And then, between those two numbers, once you subtract the amount of fish that were captured, reported captured in-river, you can come up with an estimate, which can be converted to en route loss.

Now, prior to that, the agencies would call the difference between these numbers as an escapement discrepancy. And an escapement discrepancy can emerge -- a variability in escapement discrepancy can also be attributed to unreported harvest as well as errors in the estimates that went into calculating that.

So the escapement discrepancies from 1977 to the early 1990s were relatively small compared to the escapement discrepancies that existed after the early 1990s. After the early 1990s, the management agencies were ascribing the escapement discrepancies to en route loss. So an en route loss, then, is a fish that disappeared during the migration, and presumably most of the en route losses in recent years are being ascribed to mortality although, of course, there's other factors involved.

Q So let's just back up for a second and see if I can take us through that a little more slowly to make sure I've go tit. You received data from, is it, from the Department of Fisheries and Oceans --

DR. HINCH: Yes.

Q -- and the Pacific Salmon Commission?

DR. HINCH: It was from DFO, but they would have -- the datasets are shared between both groups.

Q Okay. And what was the time range of the dataset you received?

DR. HINCH: 1977 to 2008.

Q Okay. And the specific information you received was, first, information about the count admission?
DR. HINCH: Yes.
Q Okay.
DR. HINCH: Yes.
Q The second set of data you received was spawning numbers?
DR. HINCH: Yes. Actually, I received the estimates of en route loss. They did the calculations.
Q They did the calculations?
DR. HINCH: They calculated the escapement discrepancies and then calculated en route loss. I was provided with en route loss, total spawning return, and harvest.
Q Okay.
DR. HINCH: So I could put in context for a given run what was the relative component of a run that was en route loss relative to what made it to spawning grounds or what would have been harvested.
Q Okay. And the formula for coming up with the number for en route loss is the number at Mission minus the number of spawners minus the reported catch?
DR. HINCH: Right. That gives you the escapement discrepancy.
Q Okay. The escapement discrepancy, in terms of what we're speaking about here, is synonymous in at least your work, with en route loss?
DR. HINCH: Since the early 1990s it's been synonymous with en route loss.
Q Okay. Now, was the data that you received consistently collected across the time period?
DR. HINCH: I guess. Yes, it was consistently collected. I mean, we have data for every year. In terms of how it was collected, I can only speak to my understanding of -- there are, in some years, larger errors associated with the Mission facility than in other years. Some years I know there was some issues there. I can't speak to the issues of unreported catch that could be included, or effecting some of these numbers. Spawning ground assessment procedures, I believe, are relatively unchanged.
Q In terms of the accuracy or the reliability of the data you have, do you have an equal degree of confidence for the -- over the whole time period, or are there time periods over which you have

greater confidence in the data you were provided?
DR. HINCH: I have a fair bit of confidence from the 1992 onward period. Prior to 1992, there was very little in the way of en route loss reported in the dataset. There were management discrepancies -- sorry, escapement discrepancies reported, and that's published in another paper that I cited. So I can't explain why en route loss wasn't reported, at least to a small degree, in those earlier years.

To be fair, escapement discrepancies were relatively small in that earlier time period compared to what it was in the latter time period. And most of the colleagues that I would interact with in the management agencies believe that -- and certainly they use the en route loss since '92 to the present as an index of en route mortality.

So the telemetry data I report is what I would call en route mortality. The other information in those figures are en route loss. In recent years, en route loss is being used interchangeably in the management agencies with en route mortality.

Q Okay. Now, using en route loss interchangeably with en route mortality makes the assumption that the loss is attributable to the fish dying?
DR. HINCH: Correct.
Q Okay. And to the extent you're conducting an analysis with en route loss, how would your calculation of en route loss, or anybody's calculation of en route loss, be affected by the reliability of the count admission?
DR. HINCH: Well, it can be affected by that and it really depends on which -- if it's unreliable, in which direction it's become unreliable for a given year. And so my assumption has been that, since '92 to the present, that any unreliability then, if it occurred, is not occurring just -- it's occurring the same way each time --
Q Okay.
DR. HINCH: -- so that, you know, in a relative sense, these en route losses are somewhat equivalent in terms of the scale of error, although certainly there could be some more error in some years than others.

What makes me more confident in the recent time period that the en route loss is a

reflection, an index, of en route mortality, is how it compares to the telemetry data.
Q Okay.
DR. HINCH: And certainly in recent years the management agencies have been using telemetry data to support their en route loss estimates.
Q Okay. Do you make a similar assumption with respect to the count, the number of spawners?
DR. HINCH: I don't have any reason to believe that the quality of that data has changed significantly over the 20-year period, although I don't -- that's my sense. That's my feeling.
Q And I take it you're also assuming, in conducting this analysis, that the reported or estimated catch that's used in calculating en route loss is an accurate reflection of actual catch or harvest?
DR. HINCH: It's an accurate reflection of reported catch.
MR. McGOWAN: Okay. Perhaps now is a good --
THE COMMISSIONER: Mr. McGowan, would this be a good place for a break?
MR. McGOWAN: This would be a good place, thank you, Mr. Commissioner.
THE REGISTRAR: The hearing will now recess for 15 minutes.

(PROCEEDINGS ADJOURNED FOR MORNING RECESS)
(PROCEEDINGS RECONVENED)

MR. McGOWAN: Thank you, Mr. Commissioner.

EXAMINATION IN CHIEF BY MR. McGOWAN (cont'd):

Q Dr. Hinch, you have been giving evidence about the information you received regarding *en route* loss and how that's calculated. I take it from reviewing your report, you also received or examined information regarding river temperatures over time.
DR. HINCH: Yes. Yes.
Q Okay. And you did an analysis of the relationship between the *en route* loss and the river temperatures, you examined those two factors?
DR. HINCH: Correct.
Q Okay. I wonder if you can address the Commissioner and explain to him what you identified in terms of trends.

DR. HINCH: Well, it's actually figure 2.10 in the report.

Q If we could have page 92 up, please.

DR. HINCH: So just like when we were looking at the telemetry results and trying to look at survivorship based on telemetry, and encountered river temperature, we created this figure which looked at the level of *en route* loss in relation to a 31-day temperature experience, which would encapsulate the migration of a run-timing group, and each dot is either the Early Summer or a Summer run-timing group over the period of 1992 to 2008. And we're just looking at when mean temperatures exceeded 18 again; 18 came from our telemetry results that suggested that was an important break point for survivorship.

And indeed, the *en route* loss data did show a positive relationship with mean 31-day temperature exposure in a way that was consistent with the telemetry data. And in particular with mortality, *en route* loss to a degree starting to be, you know, occurring at levels that you might consider significant about 20 percent or so, and then increasing from that point onwards.

And when you get to 19 degrees, you can see the *en route* loss estimates are about 40 percent. And indeed that corroborates well with the telemetry data which suggested about the same sort of *en route* mortality at about that temperature for several of the stocks.

So this was, in my mind, a confirmation at least that recent years of *en route* loss data, *en route* loss values, did reflect an element of *en route* mortality in that the *en route* loss and the telemetry-based mortality are showing similar patterns with temperature.

Q Okay. So this figure we're looking at here, figure 2.10, it doesn't tell us anything about trends over time. It simply articulates a relationship between mean 31-day temperature and percentage of *en route* loss; is that right?

DR. HINCH: Correct.

Q Okay. If we step back for a second, in the context of rising river temperatures, can you give the Commissioner any information about what you identified in terms of a trend over time for *en route* loss.

DR. HINCH: Sorry, could you say that again?

Q You told us we're existing in the reality of rising river temperatures.

DR. HINCH: Yes.

Q Two degrees over the last many years.

DR. HINCH: Yes.

Q And perhaps a degree in the last 20 years.

DR. HINCH: Correct.

Q Is that right?

DR. HINCH: Yes. Yes.

Q Okay. In that context, what have you seen occurring with the percentage of *en route* loss?

DR. HINCH: Oh, across the various stock groups is this...

Q Yes.

DR. HINCH: Okay.

Q Over time.
DR. HINCH: Over time. Okay. I guess that might best be reflected, then, by figure 2.7 and that's page 89.
Q Just before we get to figure 2.7.
DR. HINCH: Oh, I'm sorry.
Q Figure 2.7 is going to allow you to discuss with the Commissioner the --
DR. HINCH: The stock-specific.
Q -- stock-specific information.
DR. HINCH: Yes.
Q What I want you to address first, Dr. Hinch, is the issue of whether *en route* loss has been increasing.
DR. HINCH: Oh, I'm sorry. Yes.
Q Generally.
DR. HINCH: I'm sorry, I didn't understand. Yes.
Q I'm sorry.
DR. HINCH: Right. And certainly there's a series a figures that I included where you're looking at the percent of the run that is *en route* loss. We stopped talking about this right before the break. And that in 1992 onwards you start seeing a lot of higher levels of *en route* loss and you notice that since 1996 there's been *en route* loss of at least 30 percent in at least one of the run-timing groups each year. Also you see much higher *en route* loss in the most recent years in several of these stock groups. Now, some of the run-timing groups aren't showing as large *en route* loss as the other ones, and that might be where we're heading with the next figure that I want to talk about.
Q Okay. Well, let's go to that figure now.
DR. HINCH: Okay.
Q And I understand that what you're going to tell us here, or provide the Commissioner, is some information about the variability of *en route* loss between stocks.
DR. HINCH: Yes. And this summarizes all of the *en route* loss information by major stock, major population, which are indicated on the bottom axis. And what I did is I just looked at the number of years where *en route* loss was, in my view, considerable. So something over 50 percent I felt was considerable. And I looked at the number of years during the time period of '96 to

2008, where we had *en route* loss greater than 50 percent, and I just summarized it for the various major populations.

And what you can see is a pattern with the earlier runs, the Early Stuart and some of the earliest of the Early Summer runs, experiencing half of their years of greater than 50 percent *en route* loss or more. You also see that some of the latest of the Late runs are also experiencing high numbers of years with *en route* loss. And so this pattern of very early and very late runs exhibiting high *en route* loss is quite consistent with not just the telemetry data, but our physiological understanding of how populations cope with both warming temperatures and prolonged exposure to warm temperatures.

Of particular note is in the middle of that figure you see the bars being very small or non-existent. And so here we're looking at Summer run stocks that are doing better in terms of *en route* loss. They are coping better. There's not as much *en route* loss in the Summer run groups of fish. And again you'll see Chilko there as being this particular super stock that has not had any years during this dataset that showed *en route* loss greater than 50 percent.

So this pattern is again supported by a lot of the laboratory results that suggest that stocks that historically have migrated under really high temperatures are able to cope with increasing temperatures. The stocks that normally encounter cool temperatures don't cope as well when temperatures are warming, or when they have to encounter warm temperatures for prolonged periods of time.

And that is in particular the case for the Late run sockeye, the black bars, where all components of all Late run stocks since 1996 have forgone their typical Strait of Georgia holding pattern and migrated into the river anywhere from two to six weeks ahead of their historical norm. That began in 1996 and persists to the present. And for the stocks, for the individuals that do that and that come into the river earlier, they are coming into a river situation where temperatures are now five to six degrees above what they otherwise would have experienced

historically.

And as you may recall from my early figures, a five- to six-degree temperature change is dramatic, and in this case a rapid, dramatic change in what they historically experienced. And you may also recall from that figure that I said the difference between their optimum temperatures and lethal temperatures is about that range of about five to six degrees.

So those fish have pushed themselves well out of their optimum and into lethal temperatures, plus they're spending way longer in freshwater than they ever did before because they haven't spawned earlier. These fish are coming into freshwater earlier and going and residing in their natal lakes and holding for the same amount of time there that they would have held in the ocean. So now they're exposing themselves to the presence of freshwater diseases for a much longer period of time than they would have otherwise.

THE COMMISSIONER: Dr. Hinch, I wonder, just to clear it up for me.

DR. HINCH: Sure.

THE COMMISSIONER: On page 89, the figure you're using there.

DR. HINCH: Yes.

THE COMMISSIONER: And then on page 92 the figure you spoke about just before that.

DR. HINCH: Yes.

THE COMMISSIONER: The page 92 figure, 2.10 has temperature, mean temperature on it.

DR. HINCH: Yes.

THE COMMISSIONER: There are no temperature records on page 89.

DR. HINCH: No.

THE COMMISSIONER: Figure 2.7. Just how do I relate that?

DR. HINCH: Okay. So the figure 2.10 on page 92 is one to illustrate that the *en route* loss data is performing in the same way relative to temperature as we saw with our telemetry data. In fact, the telemetry data is on the page just prior to figure 2.10. And you can see the tipping point in the telemetry data is at about 18 degrees, where survivorship starts to decline. We see, when we start looking at 18 degrees and above with the *en route* loss data, you again see survivorship

declining as temperature goes up. And that 19 degrees is a point of reference. You certainly see about 40 percent *en route* loss and in 19 degrees with some of the stocks with telemetry you start to see about 40 percent loss, 40 percent mortality, or 60 percent survivorship.

So these two figures are intended to show that the *en route* loss data in recent years is reflecting *en route* mortality insofar as that the mechanisms of mortality, being temperature, are consistent.

The figure 2.7 on page 89 is a summary of just the patterns of *en route* loss to show which stocks are showing highest levels and which stocks are showing lowest levels. And in that case the ones that are showing the highest levels are also the ones that the laboratory studies have suggested would not cope as well with the warmer temperatures. And the ones that are showing the best survivorship, the laboratory and telemetry studies are suggesting they would cope the best with the highest temperatures. So that's where the temperature link comes in.

MR. McGOWAN:

Q So if I can just bring you back to figure 2.7, the stocks in the centre, such as Chilko, traditionally had their upriver migration during the hottest time?

DR. HINCH: Correct.

Q And those, the outlying ones at both the far left and far right-hand side, typically migrated during cooler times?

DR. HINCH: Correct.

Q And this chart may be indicative, one explanation may be that those that traditionally migrated during warm temperatures are coping better with increased river temperatures or rising river temperatures?

DR. HINCH: Yes. And laboratory studies on Chilko data suggest they have one of the greatest metabolic scopes in terms of their temperature performance.

Q Okay. Well, that takes me nicely to my next question. It looks like there is some variability of optimum temperatures and critical temperatures. Is there also a range of temperatures that can be tolerated that may be greater or smaller between stocks?

DR. HINCH: Yes. And certainly you saw a bit of that range in that one figure I showed earlier with the three populations. You saw the shape of the curve is the same, but the ends of the curves may be wider or narrower, depending on the historical temperature experience. And what we've been able to show is that the historical temperature experience during the river migration is tightly linked with the shape of that curve.

And in particular for Chilko fish, what makes them so unique in many ways is that not only are they experiencing really high temperatures during their river migration in the middle of summer, but they also experience really cold temperatures shortly after they get out of the Fraser and into the Chilcotin, which is a glacial-fed system. Quite a unique system, a unique population that they experience this wide range. So they are capable of coping with a wide range, both at the high end and at the low end and you don't see that sort of historical encounter for a lot of the populations, which generally are only getting a much more narrower range.

Q Thank you. You talked a moment ago about the Late run sockeye and their recent early entry.

DR. HINCH: Yes.

Q And tell me if I've got it correct, but in the context of this early entry migrating, spending increased time in freshwater at warmer temperatures, they've been experiencing significant *en route* loss.

DR. HINCH: Right. So they've been hit by three different thermal challenges. The first, of course, has been the general climate warming issue that I brought up earlier, with a warming in the last 20 years of up to a degree that they've all been experiencing.

They also are experiencing an additional four- to six-degree warming, by virtue of the fact that they're coming into the river several weeks ahead of schedule, and they're actually encountering in some cases peak summer temperatures, whereas they normally would be encountering cool fall temperatures when they come up.

The third thermal issue is that they're encountering what we call higher numbers of degree

days. So a degree day is the number of degrees of temperature that a fish encounters in a given day. So if a fish is encountering 30 degrees for one day, that's 30-degree days. If they encounter that over two days, that's 60-degree days.

We've calculated for Late run sockeye that there's a certain number of degree days over which they can persist in a healthy state during their migration. It seems to be for Weaver population about 500 degree days. Once the degree day accumulation gets over that, we start to see natural diseases really take over. Things that would normally not kill them till they are about to spawn or after they've spawned, actually are taking a toll on them prior because they're spending that much longer in freshwater and degree-day accumulation is that much higher.

Q Okay. With respect to what we've been seeing in terms of early entry of Late run stocks, have you done any work examining potential explanations for that?

DR. HINCH: I've focused on a couple, and there's certainly lots of other investigators who have been looking at additional mechanisms. I summarized some of the mechanisms, some of the major ones anyhow in the report. This all emerged from a multidisciplinary program that would have begun back in the early 2000s that was brought together by DFO, the Salmon Commission, and various academic groups.

There were a multitude of hypotheses put on the table back then to explore, and over time a few of the hypotheses have dropped off the table, but they don't seem to be supported by the data. But several of them are still on the table in terms of explaining potentially why these fish are migrating in early.

Q And what are the leading candidates?

DR. HINCH: The leading ones so far have to do first with fish are physiologically compromised in some fashion, and this is causing them through a variety of physiological means to migrate in early and forsake that holding period. The underlying mechanisms have to do with advance maturation, increased a system that believes it is in freshwater so their system that regulates their capacity to live in the marine environment is

altered in some fashion, and so they have to leave the marine environment and come into freshwater. And the third would be some form of disease issue that might be pushing them into freshwater. These are sort of the underlying physiological leading mechanisms.

There is a strict environmental one that has been proposed by some colleagues who suggest that it has to do with the changing salinity concentrations in coastal areas and also in some of the high seas areas that is changing the environment in a way that the fish are believing they are changing their system so that they have to migrate into freshwater because they are closer to freshwater, and there is support for that one as well.

The third hypothesis is called "stay with the school" hypothesis, which some have suggested has to do with the relatively larger abundances in recent years of Summer run fish. Now, Summer run fish don't hold in the Strait of Georgia. They generally migrate straight in. Late run fish and Summer run fish show up in the Strait of Georgia at the same time. That hasn't changed. What's changed is the Late runs are now migrating into the river generally earlier than they once did. The hypothesis suggests that the high abundance in recent years of Summer fish is enticing in a behavioural fashion these Late run fish to migrate in with them.

There is support for all of these hypotheses and none can be excluded at this point based on the data available, but research is continuing into all of them, as I understand it.

Q Okay. Thank you for that summary. We've talked now about the trends that have been observed. You've told us about increases in *en route* loss and you've talked about the relationship or potential relationship between *en route* loss and temperature. I wonder if you can offer to the Commissioner your thoughts on potential mechanisms that may explain this relationship.

DR. HINCH: Once these fish get in, when the fish come into river early, or just in general?

Q No, sorry, in general.

DR. HINCH: Okay.

Q The relationship between temperature and *en route*

loss and why might temperature lead to increased *en route* loss.

DR. HINCH: Right. So I --

Q You'll recall - sorry, just to interrupt - you'll recall when we were looking at the chart.

DR. HINCH: Yes.

Q I left aside the issue of *en route* loss in returning adults.

DR. HINCH: Okay.

Q And that's what I'd like you to deal with now, please.

DR. HINCH: All right. So there's a suite of things that can happen to a fish when it comes into a river that temperature is going to affect.

I've already shown that there are critical high temperatures that will have an acute effect on survivorship. These have to do with the metabolic ability to swim, and I didn't show data on this, but similarly the ability of the heart to perform. Both of these show same sorts of relationships with warm temperatures in that the metabolic and cardiac systems can cease operation at certain critical temperatures. And this would result in acute mortality, something that could happen relatively quickly if a fish were to encounter a really high temperature.

If temperatures are not critically high, but still relatively high, other processes are going to be ongoing, which would include the more rapid metabolism of energy. They have a limited energy store. And they can use up their energy reserves under certain conditions as a result of high flows or high temperatures.

Also at the same time you're going to have the proliferation of diseases occurring, and in many cases diseases are temperature dependent. And so although these fish come back with lots of diseases or they pick up lots of diseases, higher temperatures are going to allow those diseases to be expressed more rapidly and then the combination of these factors then can cause fish to perish in a more chronic sense.

Underlying all this is stress. These fish are stressed during this, and the build up of stress metabolites, just like we get stressed when we're sitting here talking to large groups of people with a microphone in front of you, my

glucose and my cortisol levels are really high right now, and these fish's glucose and cortisol levels get exceedingly high under high temperatures and handling and other sorts of stressors, and those can also create conditions for mortality.

Q I just wanted to go back to the disease point for a second. With respect to diseases and the increase of disease in warm temperatures, are you talking about the onset of disease, or the progression of disease, or both?

DR. HINCH: Both.

Q Okay. Now, some of the data you have identified, identifies significant quantities of loss.

DR. HINCH: Yes.

Q Between Mission and the spawning grounds.

DR. HINCH: Yes.

Q Many, many fish. And has any sort of consideration been given to whether or not the carcasses of these fish have been located in the river, or seen in the river, observed?

DR. HINCH: Mm-hmm. There's been some studies done on what happens to carcasses, or what happens to salmon as they die, and the most recent studies show that salmon as they're dying have a specific gravity that's greater than 1, which means they sink. And the only time carcasses, and this has been shown in other species, the only time carcasses start to float is when a bacterial and fungi decomposition takes over and gases then are emitted and the carcass could float under those circumstances.

However, in our experience with telemetry studies in the Fraser, the sinking is fairly rapid of these carcasses and they get covered fairly quickly with sediments and they get scavenged fairly quickly. And once the carcass is broken open in any fashion by a scavenger or even bacteria, then the gases don't cause carcasses to rise. They stay on the bottom. And certainly in telemetry studies we've done we've witnessed this with carcasses sinking and staying on the bottom.

Q So did the lack of observation of great quantities of fish floating in the river cause you any concern about your suggested relationship between temperature and *en route* loss?

DR. HINCH: No.

Q Okay. Are there other variables that may also be related to temperature that may come into play. For example, it may not be difficult to imagine that when temperatures are higher and the weather's nicer, more people are out fishing.

DR. HINCH: Mm-hmm. Well, that's an added stressor to these fish. So if water temperatures are warm and you have any type of additional handling on these fish, and there's some early research into this already that shows that, yes, under certain temperatures and additional handling, you start to reduce that scope even further. And so at issue still is what are those temperatures and what level of handling crates significant concerns. But it is something that I think many of us are well aware of as can be an issue, and we and others are certainly working towards looking at what those temperature levels are that would help us in understanding how much stressor or what level of additional stressor could cause additional problems in terms of mortality.

Q Did the telemetry studies tell you anything about whether *en route* loss is more likely to be explained by unreported catch or by death by some natural cause perhaps related to temperature, in terms of where the fish were observed to have died?

DR. HINCH: In terms of the telemetry data.

Q Yes.

DR. HINCH: So that's *en route* morality. *En route* loss, yeah, we can't, *en route* loss, fish could disappear for other reasons that we don't have information on. But in terms of telemetry, when the log lists of telemetry data gets summarized by the groups that collect it, they are very good at removing not just reported catch, but what are believed to be estimates of capture based on known reporting rates and non-reporting rates. And so a lot of that information gets factored into the mortality. Certainly it's possible that some *en route* mortality could be caused by fish that are disappearing in the river through other means, but in most cases what we're seeing is an area where we're seeing a lot of mortality is often in areas where fishing is not occurring because the mortality is often occurring in lakes. The fish go into lakes. They don't come out of lakes.

Q Okay.
DR. HINCH: And we've witnessed them disappearing into the bottom of lakes in many cases.
Q Okay. Thank you for that. I want to turn now to deal with the portion of your report which touched on pre-spawn mortality.
DR. HINCH: Yes.
Q Okay. I wonder if you can just explain to the Commissioner what pre-spawn mortality is.
DR. HINCH: So it's a way of quantifying the number of females that reach spawning grounds successfully but don't successfully lay all their eggs or most of their eggs. This particular metric has been collected from many stocks over, well, since the late 1930s and it's probably one of the best datasets anywhere for sockeye in that regard.
Q How does one assess the quantity of pre-spawn mortality on a particular stock?
DR. HINCH: You have to physically find a carcass, cut it open and see if most of the eggs are still inside of it, and then you count that as yes or a no.
Q Okay. What are the possible explanations for a fish reaching the spawning ground but not depositing its eggs?
DR. HINCH: Again, it's nothing that would say it's one single item. There's research is suggesting that it has to do with a combination of fish diseases, which they are picking up during the migration, river temperature, both during the migration and on the spawning grounds. The rate at which natural senescence occurs.

So these fish, you have to remember from the moment they are entering freshwater they are on a trajectory to die. They are all senescing just like we all senesce as we get older, our bodies, our immune systems start to break down. Their immune systems are becoming dysfunctional during the freshwater migration, and when they get to the spawning grounds, their immune function is almost nil. They have no ability to fight off infections or diseases by the time they get to spawning grounds.

They are going through rapid, rapid changes in their physiological systems that are irreversible at that point, with reproductive hormones and stress hormones flying up the charts.

So on top of the natural diseases that they may be encountering and incubating within them, they also have these rapid changes in their body physiology that's occurring naturally, and the rate at which that changes on spawning grounds not only is mediated by temperature, but also by the density of fish, as well as the amount of time they spend once they're on the spawning ground looking for a mate.

Q Did you identify any recent trends in the degree of *en route* mortality -- pardon me, pre-spawn mortality?

DR. HINCH: Yes. Looking at the data since the early '30s, and this was -- I only had access to data mostly at the run-timing level. At the run-timing level there were a few years when we had high pre-spawn mortality. But on average over the whole time period it was about 10 percent. There were some years and some groups when it was much higher than that, and certainly the Gilhousen 1990 paper that I mentioned looked at all stocks, does do a good job of reflecting just how variable it can be.

The only potential trend there might be in the past 20 years may be with some of the Late run stocks where we have seen much more variable and what seemed to be higher pre-spawn mortality for some of the small groups of fish, like Cultus and Weaver.

Q Okay. Did you identify a relationship between temperature and pre-spawn mortality in the work you were doing?

DR. HINCH: No. Not in the work I did. Others have suggested over different time periods that temperature plays a role and my best analogy for this is that pre-spawn mortality in all likelihood is a continuation of what's going on during the migration. So the factors that may be killing fish chronically in the river may not finish them off in the river. It may finish them off on the spawning grounds. And so in many cases these are things that are a carryover from one stage to the next.

Q Okay. We've talked about temperature --

THE COMMISSIONER: Dr. Hinch, I wonder if I could ask you just for clarification.

DR. HINCH: Yes.

THE COMMISSIONER: You described to counsel the changes that take place as the fish enter the freshwater for their migration.
DR. HINCH: Yes.
THE COMMISSIONER: And they're on a trajectory you said.
DR. HINCH: Yes.
THE COMMISSIONER: To dying. You've also talked about what warm water might imply for their survival. How do I relate those two? They're on a trajectory to die, in any event.
DR. HINCH: Yes.
THE COMMISSIONER: Are you saying that warm water highly escalates that death rate or...
DR. HINCH: Yes.
THE COMMISSIONER: Is that what you're saying?
DR. HINCH: Yes.
THE COMMISSIONER: And have you measured that?
DR. HINCH: Yes. Well, what warm water does is it increases, the natural trajectory to die largely involves the shutting down of immune systems. It also largely involves the escalation of certain reproductive hormones. So things like testosterone, as an example, start to build in the fish. They are using these hormones to change their bodies. They're changing the shape of them, the colour of them, they're using that to help develop the eggs and sperm. Stress hormones impede that so it affects their ability to spawn. High stress is inversely proportional to the development of those reproductive hormones.

On the other hand, high temperature is going to have a much larger effect on a fish when its system is suppressed. So in a fish that's having its immune system suppressed starts encountering higher temperatures than normal, it's not able to cope with the diseases that it otherwise would have been able to cope with for as long a period of time as it used to be able to cope with those.

THE COMMISSIONER: I wasn't very articulate.
DR. HINCH: Okay, sorry.
THE COMMISSIONER: What I was trying to get is there are fish still making it to the spawning grounds.
DR. HINCH: Yes. Yes.
THE COMMISSIONER: There are fish still spawning.
DR. HINCH: Yes.
THE COMMISSIONER: But there are those who don't.

DR. HINCH: Correct.
THE COMMISSIONER: And have you been able to discern within the species, for example, that you're examining, why you would have that vast discrepancy.
DR. HINCH: Yeah. So and this goes back to the telemetry studies that we did where we were taking little blood samples or tissue samples at the time of sampling. And we've done this with fish sampled in the ocean, with fish sampled in the Lower Fraser River and with fish sampled close to the spawning grounds and with fish sampled on spawning grounds. And what you can see as a consistent pattern is the fish that tend to survive have a certain physiological signature. Those that tend to die before spawning or before getting to the spawning grounds have a different psychological signature.

So those that perish in advance of spawning generally have high stress levels in their blood. They generally have indications of disease or immunosuppression. They tend to be advanced in their maturation sense but it's out of time. It's out of sync with when they should be having those advanced maturation signals. And in the case of the Late runs in particular, we see these fish with systems that are prepared for freshwater long before they should be prepared for freshwater. So there's something in those particular fish that is askew with them in terms of their basic physiology at the time that we're doing some of this tagging.

But the consistent thing is that, yes, there are physiological differences between fish that survive and fish that perish and you can identify this in advance of them getting to the river. You can identify this on the spawning grounds as well, or in places in between. So there definitely can be an explanation.

If you want to ascribe a name to it, you know, is it this disease or that disease, it's not that simple and we haven't been able to do that.

MR. McGOWAN:
Q Are you able, given information about temperature, to predict the extent of increase in *en route* loss that may be experienced? For example if we knew that the temperature in a particular year was two degrees warmer than the average.

DR. HINCH: Yes, okay. Yes.
Q Is it possible to calculate the likely impact on the returning stocks in terms of additional *en route* loss that may be experienced?
DR. HINCH: Yeah. In fact, the management agencies do that right now. We call these management adjustments, and the DFO and Salmon Commission assess both, well, in-season using river temperature and river flow data, what the likely impact is going to be on a particular run. Are they expecting it to be particularly hard for them in terms of temperature in this case and, if so, based on historical relationships, how many fish might you expect to perish as a result of that particular expected temperature. And knowing that information they have been able to then adjust harvest in-season to ensure that more fish pass the fishery to reach spawning grounds than other would have been allowed to go up. And that's termed a management adjustment.
Q Okay, thank you. With the prospect of river temperatures continuing to increase, we have sockeye that have been with us for many, many thousands of years, and have adapted to all sorts of changing conditions, what can you tell the Commissioner about in your opinion the species' ability in the Fraser River to continue to adapt at the rate river temperatures are increasing.
DR. HINCH: Okay. So what we've seen so far is that the stocks that migrate in the middle of summer seem to be well adapted to dealing with high temperatures and likely warmer temperatures than they're currently experiencing. They're going to be able to cope better. However, their ability to adapt further, the literature suggest, may have reached its capacity. Other studies have suggested that within large groups like this, the stocks that have evolved and have adapted this far may not be able to adapt any further to changes.
We have stocks that are coming in, that the Early and Late runs that are now experiencing either much higher temperatures or much longer degree-day accumulation. Can they adapt and cope? There's been some recent analyses done as an example on Early Stuart sockeye to see what would they have to do to be able to deal with these higher temperatures.

The most likely way these stocks will adapt and hence evolve will incorporate changes in their migration timing. We've seen this already occurring in the Columbia River, where sockeye there are now coming back much earlier than they once did, and it seems to be to avoid the high temperatures that they used to encounter. We're seeing steelhead in the Columbia migrating in later apparently to avoid the high temperatures that they would have encountered. We've seen this with Atlantic salmon in Eastern Canada, as well.

So the most likely thing that these fish will do is alter their behaviour, which can have a genetic component and could be under strong selection. If Early Stuarts were to migrate in earlier by a week to ten days earlier, some preliminary work done out of the University of Washington suggest that they could increase their chances of persisting into a warmer future.

The problem with these sorts of analyses and this way of considering things is that this is just the one life stage that we're talking about. The other life stages are also changing or the environments they're experiencing are also changing. We have changes in the lake rearing conditions, changes potentially in the spawning stream systems.

If an adult can change its migration timing in a way to increase its survivorship to spawn, can the other life stages equally change their behaviours and adapt to whatever changing conditions they're going to encounter. And these multiplicative inter-life stage effects are so difficult to predict and to model and they haven't been done. I mean, the modelling has looked just at one stage where we have the best data and it suggests yes, it could help for that one group of fish, but it's a huge black box.

Q Okay. Given this lack of information about the ability to adapt at different life stages and given what we know about the variability of the capacity of certain stocks to deal with higher temperatures. What does that tell you about the significance or importance of biodiversity in the context of climate change.

DR. HINCH: Right. So biodiversity in this context, I would define as both variability, genetic

variability within a population, as well as the variability that exists between populations. Each as we can see, these populations, many of them are uniquely adapted to dealing with their local conditions.

In my view it's paramount to be able to protect as many of these populations as possible, because we don't know what environmental conditions are going to change like in all the different life stages, and there will be some populations that may be able to cope particularly well. We just don't know that yet. And having the ability of some of these populations to either expand their range or move their range is going to be important for the persistence of the species. And so this is a standard conservation biology perspective on biodiversity. It's not just mine for Fraser sockeye. I think that's the way most conservation biologists feel about most populations.

Q Okay. We've been talking for the last few minutes about the ability of the fish to adapt. In terms of, you know, given the rising temperatures, is there anything that we as humans can do to adapt to assist the fish. I mean, let's start for example with adaptation strategies. We've seen at Kemano they have a summer temperature management program which releases water to assist the fish in terms of the river temperature. Have you given any thought to adaptation strategies that may be employed?

DR. HINCH: Well, certainly that particular strategy is an important one for helping the fish cope with what they're dealing in the Upper Fraser. There has been some -- certainly I've read in some areas people have suggested cold water refuges elsewhere in the Fraser. Many of these populations that we've been talking about today, particularly the ones that are migrating into the middle of summer, the high temperatures that they're experiencing in the Lower Fraser is what's doing a lot of the damage to them, although some of them continue to experience high temperatures all the way along the migration. You would have to be able to moderate in some way those Lower Fraser temperatures that they are experiencing for one to two weeks which are high and getting higher. I'm not an engineer,

but I suspect it's quite difficult, short of draining lots of bottoms of many lakes to be able to cool the Lower Fraser in any significant way.

And we have seen that cool temperatures are really important for fish. Where we've seen it is when the fish, when sockeye either come in early or they're transiting through lakes, they go to lake bottoms for thermal refuge. Some early work we did on Weaver sockeye that don't need to use a lake during their migration found that the early migrating Late runs that came in and went to Harrison Lake and spent time in the deep cold water were much more likely to survive to spawning grounds than those early migrating ones that didn't go to the lake.

So lake thermal refugia are very important for the survivorship. This has been shown in the Columbia, in other stocks in Washington State, and we've seen it now with all the fish we track, when we track them through lakes, even if they're only in there for a day, they migrate through the bottom of the lake where it's much, much colder than through the surface of the lake. So they're receiving some thermal benefit in that way. So any thermal benefit they could be given is going to help them.

But in terms of cooling the Fraser main stem, I'm not sure that's feasible or recommended, given how important protecting these lakes actually is. And habitat protection to ensure thermal corridors and to protect the deep, big coldwater portions of lakes is what I would suggest is a really important thing that we should be thinking about in the future. So that deals with, in my view, some of the habitat temperature issues.

In terms of understanding how harvest is going to be affected. Certainly we're going to see higher *en route* mortality in the future, and possibly higher pre-spawn mortality given the temperature conditions as are expected. If this is the case, we're going to have to forsake more harvest on these fish to ensure a certain minimum amount of spawning escapement. And so that's going to have be worked into management planning. And it may be that it becomes more of an issue for certain stocks, and these are things that in some cases may be unpredictable at this point, which

stocks are going to require the most protection.
If we had an ability to predict prior to these fish getting back to the Fraser, which stocks are more likely to perish as a result of high temperature mediated factors, that would help management agencies quite a bit. Right at the moment, we don't have that ability to predict based on the physiological or endogenous condition of the fish. All we have is what the temperature is, they're likely to experience when they get to the Fraser. This can be predicted a few weeks in advance.
There's the beginnings of a research program to look at what are called biomarkers. These would be physiological signals that are strong that we can detect before the fish get into the area of the fishery or before fish get into freshwater that would allow us as scientists to make recommendations to managers that a particular group of fish are destined to perish or are not going to cope well, or a particular group of fish are going to cope well. These biomarkers are slowly being developed, and certainly I would encourage that type of research to continue because it has a huge promise to help management.

Q I just wanted to stop you for a second.

DR. HINCH: Yes.

Q You've talked about in terms of adaptation, you've talked about habitat adaptation and you've talked about fisheries management adaptation.

DR. HINCH: Yes.

Q And I take it you're now moving into some of the recommendations you made in your report about future research that would allow additional information that might --

DR. HINCH: Correct.

Q -- assist management.

DR. HINCH: Yes.

Q Just before we carry on with your recommendations, I'm wondering if you can assist the Commissioner with whether or not you have an opinion about has what you've learned, does it tell us anything about either when or where in your opinion harvest should occur?

DR. HINCH: Well, to a degree it does. We're focusing mostly on the freshwater stage of the adult migration. There's not been much research done on

the coastal phase of the migration. Fisheries occur along the coast. There's been very little research done on temperature, or oceanographic conditions, salinity conditions, and those sorts of things, in how a fishery may or may not contribute to enhance mortality there. So all I can really speak to is what we've learned from the freshwater phase of the migration.

Certainly what it suggests is that some stocks, they don't cope very well with high temperatures. A lot of these high temperatures they're encountering in the lower river, so it may be that some fisheries that occur in the lower river under high temperatures may not be advisable in the future, or at least we'll have to consider lowering exploitation rates in some of those areas, because this is where the fish are getting hit the hardest and the earliest by these high temperatures. Some stocks may be able to cope with that in those areas. And so we really need to be considering stock specific management when we're talking about how temperatures are going to be affecting, and where and when temperatures are going to be affecting the survivorship of Fraser sockeye.

Q Thank you. I interrupted you when you were talking about your recommendations.

DR. HINCH: Sure.

Q So you've made a recommendation for one area of future research and explained to the Commissioner how it might be of assistance.

DR. HINCH: Yes, how it affects managements, yes.

Q Are there any other areas that you think -- I know you've identified them at page 6.

DR. HINCH: Yeah, I won't go through all of them, and that's a summary on page 6 and 7, and they're described in more detail in the report.

I think in addition to the couple I've mentioned, the one that I'd want to leave the Commissioner with right now is, and I hope I've made the impression of the value of understanding where fish are, and the only way we can really do that in any precise way is with telemetry. We have over the last ten years seen a lot of information gathered on adult migrations, and we know a fair bit now about where they are, where they go, and some of the factors that affect their

survivorship during the -- during the process.
The climate is changing. The rivers are warming. We're only scratching the surface now under the current conditions. We don't know what the future holds in terms of how stocks are absolutely going to be affected by higher temperatures. The research that's going to inform management on that, in my view, is coming to an end because of the stopping of funding towards the telemetry systems. I'm not saying this because it's self-serving. I mean, I have other things I can do. But certainly there's other individuals and agencies that have valued this information considerably.
The other thing is that we know virtually nothing about the early life stages of these fish, the juvenile life stages, the coastal migrations of juvenile fish and certainly the open ocean migrations. This information gap has led us to why we're largely here today, because we don't know why fish were disappearing, why their production was declining, and many cases it's because we don't know enough about where they are.
It's surprisingly little amount of information that's collected just on the juvenile out-migration fish; surprisingly, shockingly little information that's collected on them. We only know a little about one or two populations of fish in any way. We don't know how temperature affects them. We don't know how early life -- early ocean life affects them. We don't know how open ocean life affects them.
Being able to utilize new technologies that are already available and that can be expanded, in my view is money well spent for having future research in form management and policy.

Q One of the issues you just raised was the need for increased information about out-migrating smolts and --

DR. HINCH: Yes.

Q -- fish at that life stage. How would that increased information assist fish managers in managing the fishery?

DR. HINCH: Well, I mean, there's the day-to-day management, you know, how many fish do you allow to be harvested, how many are you protecting. There's other types of management as well that

deals with thinking about how you're planning for future stock conservation. So it's not just about harvest management. So a lot of it has to do with understanding habitat management. And where are their habitat limitations for freshwater stages. We know virtually nothing about that.

There's a lot of concern about invasive species, huge concern about the invasiveness of smallmouth and largemouth bass spreading through the interior of our province right now and what the ramifications of that are to sockeye in particular, but certainly other salmonids. This is a deep concern that many of us have. We know nothing about what the impacts are going to be. We do know in Washington State they can have terrific impacts on native salmonids.

So understanding more about the movements, the life history, and the issues that actually cause mortality and where it causes it is critical to being able to just answer some of those basic questions that managers, habitat managers in particular need.

MR. McGOWAN: Okay. Thank you very much for that explanation. Mr. Commissioner, those are the questions I have for the witness.

This might be a convenient time to break for lunch.

THE REGISTRAR: The hearing is now adjourned until 2:00 p.m.

(PROCEEDINGS ADJOURNED FOR NOON RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: Hearing is now resumed.

MR. McGOWAN: Yes, Mr. Commissioner, I've completed my examination. The examinations this afternoon will proceed in the usual order with one exception and that is Mr. McDade for the Aquaculture Coalition is going first and all other counsel who are affected by that are agreeable.

MR. McDADE: Mr. Commissioner, Gregory McDade for the Aquaculture Coalition. I thank my other learned friends for agreeing to let me jump the queue because of a court commitment tomorrow.

CROSS-EXAMINATION BY MR. McDADE:

Q Mr. Hinch, let us start with at paragraph 50 of your report, if I could have that up on the screen, and to try and get a sense of the significance or the magnitude of this issue of pre-spawn mortality and en route loss, now as I understand it since about 1992 this commission has heard that there have been declines in productivity for the whole of the Fraser River sockeye salmon starting from a high and going down to almost not replacement status. How does this problem that you're describing fit in with that decline?

DR. HINCH: Right. So the issue of declining productivity is a little different than the issue of fewer fish on spawning grounds or fewer fish spawning successfully on spawning grounds. The productivity decline that's been reported to the commission in various forms largely looks at a metric of productivity that's determined by returning fish when they get to the river mouth. It doesn't really include the issue of en route loss subsequent to that.

Basically, that information of en route loss is put back into the indices of productivity. So it's not a simple comparison to look at the productivity indices that the commission has been looking at to a large degree and en route loss and pre-spawn mortality; however, where thing somewhat gel is that where we're seeing en route loss being relatively high in recent years and this is in particular case with the earliest of the runs, like the Early Stuart and the latest of the runs, some of the late runs, we're also seeing declines in spawner abundance in those particular run timing -- those particular runs.

Now, not all stocks are showing declines in spawner abundance. Partly that's attributable or could be attributable to how the management agencies have been compensating for some of the potential en route loss through their management adjustments. But it's also that it's not necessarily a direct link between declining spawner abundance and declining productivity, although certainly where we're seeing declining productivity in some of those groups, we're also

seeing decline of spawner abundance and increased pre-spawn mortality.

Q Well, I also understand from your report that starting in about 1992 is when you note this abrupt change in en route loss behaviour?

DR. HINCH: Starting in -- yes, starting in 1992 en route loss really starts being reported by the management agencies. In 1996 we start seeing a real large or an abrupt change in the late run sockeye en route loss values where prior to '96 it was minimal and after then it was very large, owing to the early migration phenomenon.

Prior to '92 en route loss wasn't really recorded or reported much, although it likely occurred in some years, but it likely occurred in a much smaller context, given that the escapement -- the escapement discrepancies that they were using were relatively small then compared to the escapement discrepancies that were reported since '92.

Q So it may have been occurring, but it was occurring in much smaller numbers?

DR. HINCH: Correct.

Q And we'll come back to the question of what might -- of causation later on, but I'm just still trying to get to a sense of the magnitude of these issues. If I come to paragraph 50, you've said in the first paragraph under 2.10, effects of the mortality on population trends --

DR. HINCH: Yes.

Q -- that the spawning abundance in Early Stuart and Late Run stocks during a time period when en route loss has become a significant component of the total fate --

DR. HINCH: Right.

Q -- can you give us some quantification of what you mean by significant there?

DR. HINCH: Right. Well, if you -- if we go to that -- the figures where we looked at Early Stuart loss, for instance, and that would be Figure 2.3 on page 85, we can see the black -- the bottom part of that figure, the black bars. So the black bars is the en route loss and the white bars are the total catch, the grey bars are spawning escapement. And so in terms of the total run, which those would all add up to, what we're looking at is that in the recent period we're seeing a much higher -- a

higher component of the total run being classified as an en route loss. Sorry?
Q It looks to me from that graph or chart, sorry - I guess it's a graph - that we're seeing in some years 50, 60, 70 percent --
DR. HINCH: Yes.
Q -- loss?
DR. HINCH: Yes.
Q And similarly if you go to Figure 2.6 which is on page 88, which is the --
DR. HINCH: Late Runs.
Q -- Late Runs.
DR. HINCH: Mm-hmm.
Q Again we're seeing figures that in a number of years are in the 50, 60, 70 percent range?
DR. HINCH: Correct, yes.
Q Now, I just want to ask you one factual question. As I understand these charts, that's en route loss?
DR. HINCH: That's correct.
Q Now, you also spoke about pre-spawn mortality for those fish that made it to the spawning grounds and then didn't spawn.
DR. HINCH: Right.
Q That would be additive to these black lines, wouldn't it?
DR. HINCH: That's correct.
Q It would be some proportion of the grey lines at the top of that chart?
DR. HINCH: Yes.
Q So if we were to combine these two numbers, en route loss and pre-spawn mortality, we're in numbers that exceed 70 percent?
DR. HINCH: Yes.
Q And that would make this problem the single greatest problem in terms of loss of salmon of any that you're aware of, I would suggest?
DR. HINCH: Any that I'm aware of.
Q Well, is there any other factor that exceeds 50 percent of the run?
DR. HINCH: Oh, sorry. I mean any I'm aware of like in other parts of the world or are you talking about --
Q No, no.
DR. HINCH: -- just Fraser sockeye, Fraser salmon?
Q The issues that we're dealing with here.
DR. HINCH: Oh, yes. Yes, it's quite significant,

quite a significant level of non-spawning.
Q And the numbers in absolute terms --
DR. HINCH: Mm-hmm.
Q -- when one goes to these figures is in the chart above.
DR. HINCH: Mm-hmm.
Q If we go to, say, Figure 2.6 there are -- if we go to, say, 2006, that in absolute numbers it can be as much as two million fish?
DR. HINCH: Mm-hmm. Yes.
Q And if we go to -- and that doesn't include the numbers that are shown on the other two charts where maximum numbers might be as much as 600,000 --
DR. HINCH: Mm-hmm.
Q -- in each.
DR. HINCH: Yes.
Q So we could be looking at losses of over three million fish in some years?
DR. HINCH: Yes.
Q So if we go back to page 50, if I could, the second paragraph, the -- you've suggested that the available data suggests that en route loss may be a critical contributing factor to decreasing trends in abundance.
DR. HINCH: In some stocks.
Q Yes.
DR. HINCH: Yes.
Q And the term "critical" as I understand it is a fairly significant one in science. What do you mean by that?
DR. HINCH: Very important.
Q In fact, can I put it this much --
DR. HINCH: Sure.
Q -- without that factor or but for that factor, we might not see the trends in abundance in loss of abundance that we've seen?
DR. HINCH: For those particular stocks, yes.
Q This might be the single greatest causative factor we have to look at?
DR. HINCH: Yes. For -- again, for a group of -- for those particular group of stocks that are affected by en route loss.
Q And now if I could go back to page 41, if -- now, under this section which is patterns of en route mortality, as I understand what you've said in this section and in your oral evidence, am I

correct that this early migration pattern --
DR. HINCH: For Late Runs.
Q -- for Late Runs is a significant factor in the pre-spawn mortality and en route loss?
DR. HINCH: For Late Runs, yes.
Q There's a direct correlation between those?
DR. HINCH: Yes.
Q And at page 42, the -- in the first paragraph you have there you say:

> Coincident with their change in river entry timing the early migration phenomena, en route loss became a consistent component of the fate of Late Runs.

DR. HINCH: Yes.
Q And the Late Runs are the bulk of the fish?
DR. HINCH: In some years they can be, yes.
Q So the -- under -- getting to the root causes of early migration is a fairly important question for this commission?
DR. HINCH: It's one of them, yes.
Q Because as I understand the effect of temperature, you're saying that the effect of early entry in high temperature years can lead to increased mortality?
DR. HINCH: Right.
Q But it's not the temperature that causes the early entry. It's the fact of early entry into a high temperature --
DR. HINCH: Yes.
Q -- environment?
DR. HINCH: Yes. Yes.
Q And in -- you've -- early entry you refer to at page 37 is an abrupt shift in migration behaviour.
DR. HINCH: Mm-hmm.
Q Abrupt means sudden or unexplained or --
DR. HINCH: Yes. It hadn't happened prior to '96 and suddenly this is occurring in large segments of the Late Runs.
Q All right. And so we know that for the 60 years or more that we've been studying sockeye salmon in the Fraser River that hasn't been happening and all of a sudden it starts?
DR. HINCH: That's correct.
Q And climate change has been a steady and consistent matter moving throughout that 60 years?

DR. HINCH: Mm-hmm.
Q Right?
DR. HINCH: Well, it's certainly been happening through that period. Whether it's been consistent, I don't know if I could agree to that. As I mentioned early on in my testimony, you know, the climate variability is caused by several factors: the Pacific decadal oscillations, El Niño and other greenhouse gas related issues, these things are not working together in a linear fashion necessarily. In some years you could have higher variability, more pronounced El Niño events and a weaker PDO and vice versa. So I wouldn't anticipate a linear response, but certainly there could be years when these things all create the perfect storm of poor survivorship and there could be years when they are less severe situation, at least, in a survivorship context.
So they have been all occurring. They're occurring at ways now that seem to be exacerbating one another, I would say.
Q Yes, but prior to 1992 there were warm years on record.
DR. HINCH: Yes.
Q Right.
DR. HINCH: Yes.
Q And since 1992 there have been colder years on record, right?
DR. HINCH: In the Fraser or in the marine environment?
Q In the Fraser.
DR. HINCH: Yes.
Q So -- but since 19 -- since at least for the Late Runs since 1996 we've seen a consistent pattern --
DR. HINCH: Mm-hmm.
Q -- of early migration.
DR. HINCH: Right. Then the pattern is much more pronounced in some years, a little less pronounced in other years, so as I said early on it's -- you know, the range of early entry is between two and six weeks. Some years it's up to six weeks and these fish are coming in -- large groups are coming in very early. In some years it's not quite that long. But the pattern is consistent that it's earlier than the historic norm.
Q And there was nothing in the climate change field that was sudden and abrupt in 1992?
DR. HINCH: No, not that I'm aware of.

Q So we've got to look for some other causative factor?
DR. HINCH: Mm-hmm.
Q That's a "yes"?
DR. HINCH: Yes. Mm-hmm. Sorry.
Q So if I could go to page 38, I want to just ask you about one more point. 38, the first paragraph, you note about ten lines in that that:

> These studies have demonstrated that the earlier migrants each year suffer the highest en route and pre-spawn mortality.

DR. HINCH: Right.
Q So when we're looking at losses in the 50 to 70 percent range, we have to recognize that for actually, if you segregate out the early entrants, you could see losses much higher than that, perhaps in the 90 percent range.
DR. HINCH: Yes. In the context of the whole run, the earliest ones are the ones that are suffering the highest rates of mortality, and the more normal timed you become, the less the mortality rates would be on those fish, right.
Q So it really suggests that to focus on the overall impacts of en route loss and pre-spawn mortality, that the focus must be on the early entrant behaviour.
DR. HINCH: For Late Runs, yeah. Largely it's tied in with the early entering behaviour; however, it's not just that because temperatures have also -- fish that are coming in at normal temperatures are -- sorry, at normal times are still encountering warmer temperatures than they did. They're not encountering temperatures that are three to five degrees warmer, but they're still encountering temperatures that are, you know, one to two degrees warmer. So the scale of mortality -- the rates of mortality would certainly be highest on the earliest migrants but that's not to say that mortality still wouldn't be associated with the rest of the fish in the -- that are somewhat early -- normal-timed because they're still encountering warmer temperatures, not the same scale of warming as the early ones.
Q I think I was just exercising a mathematical choice.

DR. HINCH: No, that's fine. I know what you're getting at.
Q Which is to say that if the whole of the run is impacted at the 50 percent level, but the early entries are 90 percent --
DR. HINCH: Of that.
Q -- then presumably --
DR. HINCH: Yes.
Q -- the others are less than 50 percent.
DR. HINCH: Got it. Okay.
Q Right? They might be as little as 20 or 30 percent?
DR. HINCH: Correct.
Q They might even be close to something that was historically normal.
DR. HINCH: Possibly, yes.
Q So what we're looking for in this abrupt change in salmon abundance is what's causing the early migration.
DR. HINCH: Yes.
Q In the Late Runs.
DR. HINCH: That would be very important.
Q And if we go to Figure 2.2 at page 84, we can see that a number of years those, when you factor those out, that many years those losses are clustered in the 80 to 95 or more percent level?
DR. HINCH: For -- yes, for Weaver sockeye, yes.
Q Right. So now as I understand your report, when we go to page 39, we get the causes of early migration, and this perhaps I'd like to suggest is, given what we've said so far, is a fairly significant question.
DR. HINCH: Mm-hmm.
Q Now, you've said there, if I read it correctly, that the -- that you refer in your report to the proceedings document for a more thorough summary.
DR. HINCH: Yes.
Q And you've referred to that a little further up on page 39, if I could go to the paragraph above, six lines from the bottom of that paragraph.
DR. HINCH: Mm-hmm.
Q As the most authoritative compilation of research to date.
DR. HINCH: Yes. So can I just have the proceedings document up on the screen which is, I think, number 9?
Q Now, this is the document that you're referring to

in those two places --
DR. HINCH: Yes.
Q -- as the most authoritative document on the causes of early migration?
DR. HINCH: Yes. Could I ask that that exhibit be marked?
THE REGISTRAR: Exhibit 557.

EXHIBIT 557: Proceedings, Conference on Early Migration and Premature Mortality in Fraser River Late-Run Sockeye Salmon - June 16-18, 2008

MR. McDADE:
Q Now, can I -- I'll come back to that document in a minute, Dr. Hinch. You're also the author of a document - can I have AQUA284, the .pdf on the screen? You're the author of a recent scientific study that was published in *Science*?
DR. HINCH: Yes.
MR. McDADE: Sorry, the .pdf, the report itself. It's an attached document.
MR. LUNN: Is it further down?
DR. HINCH: It's the next paper in the list.
MR. LUNN: Oh, I see. Thank you.
MR. McDADE:
Q Yes. So that's the document that's published in *Science*.
DR. HINCH: Yes.
Q You're an author of that document?
DR. HINCH: Yes, I am.
Q And you cite that document in your paper --
DR. HINCH: Yes.
Q -- that's here today?
DR. HINCH: Yes.
Q I'd just like to go to the last page of that document.
DR. HINCH: Sorry, which? The...?
Q Sorry, the page just before that. Okay. There. Yes. So that's page 3 of your *Science* report. If I could just read you the very last sentence, the conclusion of your report.
DR. HINCH: Yes.
Q

Our hypothesis is that the genomic signal associated with elevated mortality is in response to a virus infecting fish before

river entry and that persists to the spawning areas.

DR. HINCH: Okay.
Q You agree with that statement?
DR. HINCH: Yes. The hypothesis is that.
Q Yes. And now I'm wondering why, if that was your opinion, or at least if that's a reasonable hypothesis, why in the paper that you produced for this commission the word "virus" does not appear?
DR. HINCH: Right. Two reasons. The first is that when I was writing the bulk of the paper, I was under a publication embargo so I wasn't supposed to talk about or write about the *Science* paper. This is a requirement of that particular journal. I nonetheless inserted the reference in so that it would get into the document so that we could talk about it. The -- as the paper suggests and as it's sprinkled throughout the *Science* paper, this is a hypothesis and so I wanted to be clear in my report that I wrote that what we know for certain, absolutely certain, is that we're looking at an immune suppression response in the biochemical, the genomic data. That is a certainty.

What is hypothesis is that it is linked to a virus. So the way the hypothesis is actually worded in -- throughout the *Science* paper is a purported virus, so the hypothesis is a virus. All we can really talk about is a purported virus in certain terms. Clearly, there is the indication of immune suppression and that's the most certain statement we can make, based on that analysis. You can't prove a virus, as I understand it - I'm not a virus specialist - but you can't prove it until you do certain follow-up investigations which, as I understand, are underway to show that it is or isn't a virus.
Q So one reason for not referring to this directly in the paper is the embargo that was *Science* just because the matter of timing?
DR. HINCH: Yes, awkward timing.
Q Right. Did you discuss with commission counsel amending your report to include this?
DR. HINCH: Recently I did, very recently.
Q And you were told it was too late?
DR. HINCH: I was told, yeah, it was too late.
Q Otherwise you would have included it?

DR. HINCH: If this would have taken another month to bring together, yes.
Q So ideally, you'd like to amend your report to include the possibility of this virus as a causative factor?
DR. HINCH: I'm happy to talk about it right now.
Q Well, let's do that. All right. If we could go back to the first page of that report -- sorry, the -- there's a summary at the beginning. The next page, I guess. Yes. Right there. And if we could blow up the paragraph in bold. Yes. Thank you. Okay. And so in the abstract at the beginning, your team, which is set out above there, found that in -- that there was a common genomic profile that was correlated with survival. So that's the predictive biomarkers that you were discussing in your evidence this morning?
DR. HINCH: Yeah. Actually, it's before biomarkers. A biomarker is -- can come after more research from a particular gene that one may identify as being really strongly related to a particular outcome of a behaviour or a fate. In this case, this is well before developing those. This is a suite of genes, many genes, that are showing a common physiological basis that genomic scientists can interpret in terms of the physiological system that is showing response.
Q And it's that set of genes that you've hypothesized may be a purported virus?
DR. HINCH: Yeah, that the team hypothesized. Again, I'm well down the author list, as you can tell. I'm the ecologist on the team.
Q All right.
DR. HINCH: Not the genomic scientist on the team.
Q Well, in terms of what is the causation of this early entry, this would be a fairly significant finding?
DR. HINCH: Yes.
Q Yes. And the document goes on to say that in ocean tagged fish a mortality related genomic signature was associated with a thirteen-and-a-half-fold greater chance of dying en route.
DR. HINCH: Yes.
Q That's a very high number, isn't it?
DR. HINCH: Very high number.
Q Now, when Mr. Commissioner asked you this morning a question about how can we tell which fishes are

going to die and which ones aren't - I'm sorry to paraphrase, Mr. Commissioner - this is a pretty significant answer.

DR. HINCH: Yeah. And that's -- I knew you were going to ask me this, so I was leading you into this by saying that there are physiological conditions that can predispose an animal to its fate. In this case, there was a suite of genes that represented a particular physiological state that was predictive of what it was going to do later in its life, in this case perish. Yes.

Q So it was predictive of the fact that we're going to see en route mortality for it?

DR. HINCH: Right. I mean, it's done retrospectively, right?

Q Yes.

DR. HINCH: I mean, we didn't know going into this that that was going to be the case, so this is done by putting transmitters in fish, taking a biopsy sample, in this case of their gill, looking at their fate based on a telemetry system array and then doing the genomic analyses, looking at genes basically, 16 -- I think 16,000 genes, and seeing which genes are active and which ones are not active, and using that with some detective work to determine what are the -- the physiological systems that are associated then with the fate of the fish.

Q It was also associated with a 3.7-fold greater chance of dying without spawning on the spawning grounds.

DR. HINCH: Right. So we did the same sort of thing with spawning ground fish.

Q So that would be highly predictive of pre-spawn mortality then?

DR. HINCH: It -- yes. It was certainly associated with pre-spawn mortality at that level.

Q So this purported virus, if it in fact exists --

DR. HINCH: Mm-hmm.

Q -- goes a very substantial way towards explaining the early -- or to explaining the whole of the en route loss?

DR. HINCH: It could. And that's why it got published in the journal *Science*, because they're looking for these broad scale wow sorts of relationships. It's also worth mentioning, though, along with this is that prior to this -- I mean this was -- I

mean, there's limitations to every study. This is done in one year. It was 2006. We don't know -- we've never done the genomic work in any significant way much prior to that.

Some preliminary work was done in 2005. However, we have been doing telemetry work prior to that and we were looking at other physiological systems, albeit much more primitively. We were looking at plasma. We were looking at stress hormones and reproductive hormones. And we saw in earlier years fish that looked like they were compromised in terms of high stress levels with our more primitive biopsy approaches, so this in some ways was a confirmation of what we had done and I reported in our report from earlier years. Again, we're only looking at a few years, but it certainly was the state of the art.

MR. McDADE: All right. I'm going to take you there in a second. Can I just ask that this document be made an exhibit?

THE REGISTRAR: Exhibit number 558.

EXHIBIT 558: Genomic Signatures Predict Migration and Spawning Failure in Wild Canadian Salmon

THE COMMISSIONER: Mr. McDade, I just wonder if we could put the title of the document on the record.

MR. McDADE: Yes, Mr. Commissioner. Genomic Signatures Predict Migration and Spawning Failure in Wild Canadian Salmon.

THE COMMISSIONER: Thank you.

MR. McDADE: With the lead author being Dr. Miller, Kristina Miller.

THE COMMISSIONER: That's 558?

THE REGISTRAR: That's correct.

THE COMMISSIONER: Thank you.

MR. LUNN: Mr. McDade, did you want this document which is also listed at Tab 7 that's on the screen right now as part of that exhibit?

MR. McDADE: Yes, please. Really, they're --

DR. HINCH: They're actually -- they're part of the same --

MR. McDADE: -- one document.

DR. HINCH: -- document. It's just that they only -- they publish one online and one gets published in the journal.

MR. McDADE:
Q Now, if I could take you to the document that's at Tab 10, Mr. Lunn. This is a paper entitled Physiological and Energetic Correlates of En Route Mortality for Abnormally Early Migrating Adult Sockeye Salmon in the Thompson River, British Columbia, and you're listed as the second author on that study?
DR. HINCH: Yes. That was my grad student who was the first author.
Q And so this was a 2006 paper?
DR. HINCH: Yes, based on 2003 telemetry data.
Q All right. So is this the earlier -- they took one of the earlier works?
DR. HINCH: It's one of the earlier ones, yes.
Q Okay. I just want to take you -- let's look at the abstract for a second. This again notes that since at least in this case since 1995 large portions of the Late Run salmon are -- have been experiencing spawning migration several weeks earlier than normal. Now, here you refer to it as aberrant migrants.
DR. HINCH: Yeah. We were advised later that maybe we shouldn't be calling them aberrant. It had other connotations. But we were just starting our research then and --
Q Okay.
DR. HINCH: -- we didn't know what else to call them.
Q So when we talk about early migrants or aberrant migrants, it's the same --
DR. HINCH: Yes.
Q -- it's the same syndrome --
DR. HINCH: Yes.
Q -- we're referring to. Now, there in your abstract, starting five lines in, you say:

> Aberrant migrants that resumed their migration but failed to reach the spawning grounds had lower gross somatic energy, higher average migration ground speeds, higher plasma --

DR. HINCH: Osmolality.
Q

> -- osmolality and higher levels of plasma reproductive hormones than those that reached the spawning grounds.

And you go on to say that:

> These fish displayed excessive bleeding during transmitter implantation, an unusual phenomenon...

And blood clotting time was decreasing steadily. So there were a number a symptoms --

DR. HINCH: Mm-hmm.

Q -- that you were seeing.

DR. HINCH: Mm-hmm.

Q Now, I understand the virus that is being hypothesized in the Miller paper is a form of retrovirus; is that right?

DR. HINCH: That's what I understand, yes.

Q And a retrovirus, one of the signs of a retrovirus is a suppressed immune system --

DR. HINCH: Mm-hmm.

Q -- is that right?

DR. HINCH: Yes.

Q And this bleeding and lack of clotting behaviour is -- would be a symptom of a virus of that sort?

DR. HINCH: It could be. In the paper, this particular paper, you know, we weren't thinking virus when we were writing this at all. We were thinking disease. And certainly it could be indicative of other types of diseases, as well.

Q So the -- the Miller paper has hypothesized a purported virus but hasn't named it.

DR. HINCH: Correct.

Q But in your discussions you've talked about salmon leukemia --

DR. HINCH: Yes.

Q -- as a possible name for that?

DR. HINCH: That was Kristina Miller's offering, yes.

Q And have you heard that referred to by fish farmers as fish AIDS?

DR. HINCH: I haven't heard of that, no, but...

Q But as a form of immune suppression --

DR. HINCH: Yes.

Q -- the -- if fish have that purported virus when they enter the river --

DR. HINCH: Yes.

Q -- their resistance to temperature may be less?

DR. HINCH: Yes.

Q Their resistance to diseases or parasites like parvacapsula may be less?

DR. HINCH: Yes.
Q And there is some indication in your papers and in the proceedings that, in fact, when the fish with this purported viral signature show up at the spawning grounds, they're not necessarily lacking in energy.
DR. HINCH: Correct.
Q So it isn't an energy problem that you're dealing with.
DR. HINCH: In most of the early migrating Late Runs probably not as the core issue.
Q The core issue could be a virus that was reducing their ability to sustain the run of issues that are coming at them all the way up the river?
DR. HINCH: It could be.
Q And now I noted that your -- your paper is based on 2006 data, did you say?
DR. HINCH: This is the *Science* paper?
Q Yes.
DR. HINCH: Yes.
Q And your charts in the report that you've brought to us today deal up to 2008?
DR. HINCH: Yes.
Q Why is there no 2009 data?
DR. HINCH: I just wasn't given it.
Q Why not? Did you request it?
DR. HINCH: No. At the time when I started this, I'm not sure it was in its final states because it was -- it takes about a year to put the en route loss data into a final state. When I started these analysis it wasn't there yet and I didn't request to update that.
Q Well, that data should be available now, shouldn't it?
DR. HINCH: Oh, yes.
Q Right. And wouldn't it be important to -- and there may be some 2010 data --
DR. HINCH: It would be preliminary, yes.
Q The -- do you know anything about the preliminary 2010 data and whether there's been significant en route loss?
DR. HINCH: My understanding, again this is just from talking to management people, there was in 2010 there was -- early migration phenomenon persisted. It wasn't -- the fish weren't as early, but they were still on the early side of normal. There was, I don't believe, as much en route mortality

as in previous years, but there was pre-spawn mortality. Again, these two things could well be linked and one's a continuation of the other.

So my understanding is that yes, the phenomenon persisted and to a degree there was losses.

Q Could I now -- sorry to jump around, Mr. Lunn, but could I know go back to the proceedings document which is Exhibit 557 at page 9. Now, again this is the document that you've relied on a great deal in dealing with this topic in your --

DR. HINCH: Yes.

Q -- in your paper. In fact, some portions of it are repeated.

DR. HINCH: Yes, they -- nothing has changed since then, so yes.

Q And if I look at page 8 when you're summarizing -- sorry, page 9, my apologies. So under the heading "Why Does Early Migration Occur?" --

DR. HINCH: Mm-hmm.

Q -- this part of the document is supposed to be a synthesis of what's known; is it?

DR. HINCH: Yes.

Q That's right?

DR. HINCH: Yes.

Q And this part of the document you wrote?

DR. HINCH: Yes.

Q And you'll -- let me address you to the sentence starting:

> Reproductive advancement...

Five lines in.

> Reproductive advancement is a key feature in coastal migration speed and in reduced estuarine holding and because the physiological changes that initiate reproductive maturation occur prior to fish reaching the coast during their homeward migration --

And you cite Miller there.

DR. HINCH: Mm-hmm.

Q

> -- the estuarine behavioural change may have its roots in the open ocean. Early entering

fish are also not healthy. Their gene array profiles reveal disease, viral, pathogen and stress responses --

And again you cite --

DR. HINCH: Mm-hmm.

Q -- Miller. This is not the Miller paper that we looked at here.

DR. HINCH: No.

Q This is the Miller papers that were --

DR. HINCH: Yeah.

Q -- are within this document.

DR. HINCH: Although I suspect if the analyses on -- the data that were used in those were many of the same data that were ultimately used in the *Science* paper.

Q So it's clear that this -- this purported virus, if that's the explanation, is coming onto the fish before they enter the river?

DR. HINCH: Yes, into the -- yes. Yes.

Q It's something that's happening --

DR. HINCH: Earlier.

Q -- earlier.

DR. HINCH: Yes.

Q And you mention here:

> The fact that 50% of the fish sampled at the Queen Charlotte Islands carried the same disease signatures identified later in the migration suggest that segments of the fish populations may become ill or susceptible to diseases while in the high seas.

DR. HINCH: Yes.

Q But it's also -- you also suggest later in your paper that it may be something that is present in smolts coming out of the river.

DR. HINCH: Yes.

Q And it's something that may have an intergenerational component in terms of eggs --

DR. HINCH: Yes.

Q -- passing it on.

DR. HINCH: Yes. That's conjecture, but it could be the case.

Q Right. Because retroviruses can transmit themselves --

DR. HINCH: Yes.

Q -- through the eggs and --
DR. HINCH: Yes.
Q -- to the next generation.
DR. HINCH: Yes.
Q And you go on to say that:

> The disease state appears to alter the osmoregulatory physiology of migrants, making them osmotically similar to freshwater fish.

DR. HINCH: Mm-hmm.
Q And so am I correct to say that the conjecture at this point is that the effect of this purported virus is to cause that freshwater state that leads to the early migration?
DR. HINCH: Yes. That's the hypothesized link.
Q It says three lines further down, going on to say:

> ... it is possible that the disease state is also responsible for the advanced maturation observed in early-migrating Late-runs.

DR. HINCH: Yes. Could be. We don't know enough about -- early -- what really got us thinking about this is the -- maturation really kicks in in the high seas. This is, you know, six to eight months prior to reaching the coast is when reproductive hormones start to change as a result of growth rates and daylight length changes. So this got us thinking that whatever's going on has to be occurring at least that early in their life history or earlier.

One of the most distinctive things that we were able to pick up in all of our samples, this is before we did genomic work, was that the reproductive hormones levels were advanced. And it lends support at the time to the hypothesis that they are trying to get out of the marine environment because they are more mature and they need -- their biological clock is ticking. Similarly, as you suggested, the osmotic condition of the fish was also such that they would want to get out of the marine environment because they were more relatively speaking freshwater prepared. So both of these things seemed to be working together. We don't know how they're related, though, but they both seem to be there.

Q So my overall point, perhaps just by looking at this page, is that in terms of coming up for this whole proceedings, in terms of coming up for a likely reason for this early migration behaviour, a possible or purported virus or disease was the number one likelihood that you considered?

DR. HINCH: Well, my colleagues who contributed to this proceedings, some of them would disagree with that as the number one. I felt it was one of the leading hypotheses; however, the oceanographers that were participating felt they had very strong relationships between oceanographic indices of upwelling and salinity and that that was -- and this was a paper by -- well, it's now published. It was not at the time of the proceedings, by Rick Thomson, who's a DFO scientist, and he was showing that over the course of the early migration phenomenon that you could predict the level of early migration based on certain oceanographic indices.

The other -- and there's one other. The other one was I mentioned earlier the stay with the school hypothesis, which Karl English has suggested and is a strong advocate of and is published on, showing that the high relative abundance of Summer Runs over the last 20 years is a strong correlative factor with the early migration percentages and that the argument is that behaviourally, fish are being enticed to come into fresh water.

Now, both of those, it's not to say that both of those hypotheses aren't exclusive of the strict physiological one that I mentioned at the beginning. It's just teasing the three out and independently testing them is impossible.

Q Well, let me suggest, though, that the two that you talked about in this section were the --

DR. HINCH: Yes.

Q -- first the disease and then the salinity?

DR. HINCH: Yes. In this section, that's where the focus was.

Q And let me also suggest that the third hypothesis was largely disagreed with by the majority of people at the proceedings.

DR. HINCH: There was a vocal minority.

Q And the -- because it wouldn't explain why this was happening in 1992 on forward, would it?

DR. HINCH: Well, I think the biggest concern with that, with all respect to my colleagues who purported it, was that it seems to me there has to be a physiological basis for changes in behaviour. And we hadn't -- we weren't able to detect that, but in fairness, we weren't looking for it in the years when he was looking at it. So we couldn't test it. We couldn't prove or disprove it.
Q Okay. But in your personal opinion --
DR. HINCH: Yes.
Q -- the disease is the leading cause --
DR. HINCH: The --
Q -- leading likelihood.
DR. HINCH: Yeah. I'd like to -- instead of calling it disease, just to be fair to everything, it's immune suppression, immune suppression response, which you can interpret as a disease, yes.
Q Now, do you have a -- have you had any success in determining the cause of that immune suppression response?
DR. HINCH: This is not what I'm doing. That's not my research. My understanding from those that are pursuing this, and that would be the lead author on that *Science* paper is that headway is being made, but I couldn't tell you. I don't know what the current science is on that.
Q Okay. But in terms of looking for a cause, do you find it significant that you see a much lower percentage of the unhealthy or purported viral signature in those fish coming through Juan de Fuca than you do from fish coming through Johnstone Strait?
DR. HINCH: I don't --
Q That's correct, isn't it? There is a difference?
DR. HINCH: That's my understanding.
Q Yes.
DR. HINCH: Yes.
Q And for instance, the Harrison stock is quite -- is the one stock whose productivity is increasing?
DR. HINCH: Yeah. Are we talking juveniles or adults here, I'm sorry?
Q Adults.
DR. HINCH: Okay. Yes.
Q Yes?
DR. HINCH: Yes. Yes, the -- so keep going. Yes?
Q I mean, of all the stocks when you're looking at productivity, I think we've seen the chart in

another place, the Harrison stocks are the ones that seem to be doing the best?

DR. HINCH: They seem to be, yes. In terms of productivity, although interestingly, in terms of en route loss, they suffer high en route loss, as well. If you look at that one figure of mine, you'll see that.

Q The -- now, so if one is looking for a cause that was triggered in the 1992 to 1996 period, wouldn't you look for some causative factor that's new in that period of time, that's on the migration route of these fish?

DR. HINCH: Yeah. I guess. We weren't looking for -- we were looking for, in our hypotheses, at the time looking at what environmental factors could possibly be changing that was consistent with our understanding of migration physiology. Given that the -- what we've learned recently, that the genomic signature at the Queen Charlotte Islands seems to be similar to the genomic signature that is reported later on in the adult migration in, for instance, Johnstone Strait, it was telling us that whatever is happening to these fish is affecting them prior to them making landfall as adults.

In terms of when and other factors, you know, I -- yes, I don't have other information on our thinking on the hypotheses at the time. There's a huge list of them, as you can see in that report, that we came up with that we've been trying to explore over that -- over the last ten years and some are -- many are still on the table. Some have been taken off the table.

Q The fact that chinook farms in 1992 experienced an outbreak of salmon leukemia, would that have any relevance for you?

DR. HINCH: I don't know. I don't know enough about virus-like diseases in most fish. That's just not my area of specialization.

Q In the course of your research have you looked at whether there's any evidence of this viral signature in fish farms?

DR. HINCH: I personally haven't. I'm not sure what DFO has done.

Q Well, have you seen any of the -- in your --

DR. HINCH: No.

Q -- literature search --

DR. HINCH: No.
Q -- did you run across --
DR. HINCH: No.
Q That would be a fairly important question, wouldn't you agree?
DR. HINCH: I would agree, yes.
Q Now, in your testimony this morning, I heard you talk about in terms of recommendation, specifically you talked about two recommendations. One was to increase telemetry and that was an important part of this science study --
DR. HINCH: Yes.
Q -- was it not?
DR. HINCH: Yes.
Q The other, you said, refer to continuing the research to identify biomarkers.
DR. HINCH: Yes.
Q And were you referring to this kind of genomic research in talking about that?
DR. HINCH: Yes, as an example of where -- how powerful it could be if we continued along these lines to identify individual genes that could be predictive of fate.
Q And so trying to identify the nature and source of this purported virus would be a significantly important recommendation; wouldn't you agree?
DR. HINCH: Yes. Not just the -- I mean, doing this for looking at fate in general.
Q Because I was struck when I looked through your recommendations that I didn't see that explicitly there. Is that because of the *Science* report?
DR. HINCH: Hold on a second. I want to look at my recommendations.
If you go to the full-blown recommendations that start on page 54 --
Q Yes?
DR. HINCH: -- not the abbreviated ones --
Q Yes?
DR. HINCH: -- and you go to number 3, right in the middle of number 3, I state:

> Furthermore, continued research into stock-specific effects of temperature and stock-specific biomarkers are needed. However, such research requires tagging programs in order for thermal experience and physiological conditions to be linked with their fate.

So I think it's very important.
Q All right.
DR. HINCH: That's why I put it there.
Q Well, it's sort of hidden there.
DR. HINCH: Sorry.
Q If you accept that this is a very significant or critical contribution to loss of salmon abundance, would you like to suggest that that recommendation should get a higher priority?
DR. HINCH: You know, when I wrote these I wasn't prioritizing them.
Q All right. Would you agree --
DR. HINCH: That was sort of --
Q Would you agree it should have a high priority then?
DR. HINCH: It should have a high priority. I can't say it's any higher though than any of the other ones, but it's certainly -- in my -- I wouldn't have put any down here that I didn't think were really important, so I think this one is important, very important. They're all very important.
Q When I'm asking about the proceedings that were -- that we've marked as an exhibit which were in 2008 --
DR. HINCH: Yes.
Q -- was Laura Richards from DFO there?
DR. HINCH: At the meeting?
Q Yes. I thought I saw her on the list of
DR. HINCH: She may --
Q -- attendees.
DR. HINCH: She's on the list. You know, I can't recall if she was or wasn't there.
Q Have you ever personally discussed this matter with her?
DR. HINCH: Yeah.
Q And the question of -- what about the question of your *Science* paper? Have you had a discussion with her about that?
DR. HINCH: No. I've never discussed that with her. We weren't allowed to talk to them.
Q Right. Now, so I was struck by the absence of this reference of purported virus. You have explained that the *Science* paper was embargoed.
DR. HINCH: Yes.
Q But can I ask you this? Had you had any discussions with anybody from DFO in preparing

your paper that suggested that you should not refer to that virus?

DR. HINCH: No, none.

MR. McDADE: Those are my questions, thank you, Mr. Commissioner. Oh, before I sit down, I should mark the one document that we didn't mark, which is the paper, The Physiological and Energetic Correlate which was Tab 10.

THE REGISTRAR: Exhibit 559.

EXHIBIT 559: Physiological and Energetic Correlates of En Route Mortality

MR. McDADE: Thank you very much.

THE COMMISSIONER: I wonder, Dr. Hinch, if I could just ask you arising out of those questions, just -- you said at the morning break you remarked about the -- I can't recall your exact words, but the absence of -- I don't know if you said the word "funding" but resources for doing the work that you spoke about.

DR. HINCH: Yes.

THE COMMISSIONER: You've been addressing it again in your answers now. Can you just explain to me the context in which you made that remark?

DR. HINCH: Yeah. Well, I guess you can see the impact that that *Science* paper has had or potential impact. We could not have done that without the telemetry infrastructure that was in existence in 2006 and in earlier years. The infrastructure, that particular infrastructure involved a radio receiver array, so an assortment of listening devices that were arranged up the Fraser watershed throughout the main stem and several of the tributaries and this particular infrastructure was, in this case, maintained by a consulting company, LGL. I believe the commission has heard from Karl English, one of the people who work at LGL.

This particular system has been used in various forms now since 2002, almost every year up until the present and it's been -- it's not a terribly expensive system to maintain, but it does require funds and the funds have come from a variety of sources but largely they've been piecemeal put together through Salmon Commission, Southern Endowment Funds, internal DFO funds,

Pacific Salmon Foundation funds and other sources. One year I helped get a large NSERC, Natural Sciences and Engineering Research Council of Canada, grant which persisted for several years to help fund that infrastructure, as well.

The other partner infrastructure that I mentioned this morning, is that provided through the Vancouver Aquarium through POST, the Pacific Ocean Shelf Tracking project. It's a different type of technology, but with similar objectives and the advantage of that is it can be used in the marine environment, whereas the radio telemetry array can only be used in fresh water. Together, they're very powerful tools and they -- we did use them in concert to look at both marine and fresh water movement and survival patterns.

The research that we published in *Science* and most of what's been brought up here, in fact, all of the research summarized to a large degree in that proceedings document, was based on telemetry or telemetry-like data. We know a lot more about Fraser sockeye now than we've ever known because of the Late Run problem and it was only because of the Late Run problem that we were able to garner funds from various sources together to investigate what baseline conditions were like for fish. We did not know what the physiological systems of fish were like before that to a large degree.

My major concern is that I'm seeing the deterioration of these platforms and the funding available for them and it seems to me this should be a core component of any assessment that management agencies are going to be doing. Certainly it is in other jurisdictions. And I think the information that has been collected and the management systems would agree has really gone a long way to helping them with their in-season management, their post-season assessment, and it should probably be expanded, if anything, not decreased in its level of funding and availability, considering what a powerful tool it has been.

If we're able to do this with juvenile fish and the technology exists but it needs to be significantly upgraded, can you imagine if you're able to take a physiological sample of a juvenile fish, put a transmitter in it and track it through

its entire life? We'd know where the fish is. We'd know what happened to it to a large degree. We would know what the disease or physiological condition of a juvenile is related to the adult stage. We don't know any of that. We don't know where they're going. We don't know where they're dying until they come back as adults.

THE COMMISSIONER: Thank you.

DR. HINCH: You're welcome.

MR. McGOWAN: Mr. Commissioner, Mr. Taylor is next. I didn't know if you wanted to take a brief break or just carry on.

THE COMMISSIONER: Well, if Mr. Taylor is ready, then we can go for 15 minutes and then take a break.

MR. TAYLOR: Mitchell Taylor and with me is Geneva Grande-McNeill. We represent the participate Government of Canada before this commission.

CROSS-EXAMINATION BY MR. TAYLOR:

Q And my questions will be mainly of Dr. Hinch, but if Dr. Martins has something to say, please don't be shy when I'm asking questions. Just picking up on the last exchange between yourself, Dr. Hinch, and the commissioner and tracking throughout a fish's life, it strikes me that there would be some logistical issues, big logistical issues to do with transmitters once you leave what seems to be called landfall and the fish get out into the Gulf of Alaska. Do you have anything to say about that as to whether that is a logistical issue and what you think might be done about that?

DR. HINCH: Yes. I guess the -- there's a couple logistical issues. The first would be --

Q 'Cause there's no land.

DR. HINCH: You just made me laugh there. Yes, there is no land. The -- if we were going to embark upon monitoring that would involve that, you'd be tagging fish before they left land, the freshwater areas, on their way to the open ocean. The first logistical challenge to overcome is that many of the current tags that are used are too large or on the large side for use in small fish. Now, that's been a -- that technological limitation is quickly being surmounted by the development of much smaller transmitters and tags --

Q That's partly a battery issue too, isn't it?

DR. HINCH: It's a large part of the battery issue. However, the electronics involved with the tag is also an issue. They've overcome this in the Columbia River recently with a completely new technology with transmitters that are incredibly small and cheap and it was developed through I think the American military complex had a large role in funding a lot of this and so the -- certainly it is possible and -- to be able to get small tags that can be put into fish. The other issue that deals with the battery limitation problem is that in a lot of the current tags, you can have the battery life prolonged by having a program shutdown.

And this has actually been done in a recent study on juvenile sockeye that were tagged leaving Cultus Lake a few years ago where they put these little transmitters into smolts. Now, these were large smolts, mind you, but nonetheless, the tags were programmed to shut down after a month and a half and turn back on two years later. And they did that -- well, they did turn back on, because we got a couple of fish return, so we know that the technology works and the survival rates, as I understand it - this was not my study - the survival rates, as I understand it, were equivalent to what you might expect wild fish to survive at. So that first technological issue is a major one, but it can be overcome.

The other one which is a big issue is just the sheer number of tags you're going to have to use. You know, you're looking at some marine survival rates that are quite low these days, you know, so if you want to be able to have an accurate representation of survival rates, you're going to have to put out a lot of transmitters because a lot are going to perish during the natural life before they return.

Q So is that millions?

DR. HINCH: Dollars or tags?

Q Tags.

DR. HINCH: Thousands.

Q Okay. And then is there not also the other side, that is, once this tag transmits, someone -- something has to be somewhere to hear it?

DR. HINCH: Yes.

Q And isn't that an issue that -- what are you going

to do? Where are you going to put these -- I don't know if you call them transmitters or receivers, but the --

DR. HINCH: Yes.

Q -- the thing that ends up getting the information from the fish.

DR. HINCH: Yes. In the marine environment they're usually called curtains because they create a curtain across the sea bed. So we have examples of these curtains that are already existing through POST. There is a curtain currently across Juan de Fuca Strait, one across the Northern Strait of Georgia, one across Queen Charlotte Strait, one sticking out from Lippy Point on the northeast corner of Vancouver Island, and several in the U.S., one south of us and several in the Alaskan waters.

These lines in the U.S. are being expanded as we speak. There's been more resources put into them through the ocean telemetry network. On the other hand, the lines in Canada are falling into disrepair for two reasons: one is that they've been largely funded through American philanthropists that's been funding the Vancouver Aquarium. That money is running out. And the lines, the Canadian lines now have to be upgraded due to battery issues. They only last so long before you have to replace them. And the technology, as I suggested, is changing. If we're going to be using smaller tags and new technology, the receiver systems themselves have to be replaced.

So, yes, there's infrastructure. Some of it's in place. It has to be updated, repaired and money has to be there for people to maintain it.

Now, the Vancouver Aquarium has taken on that task through outside money. My understanding is that that money is running out or is about to run out.

Q Now, am I correct though that the curtains, as you call them, are -- the infrastructure is mostly land-based, although there's some put at the bottom of the water, as I understand it, but these curtains have transmitters or receivers, whatever they are, somewhere on the land and --

DR. HINCH: No, that --

Q -- the tags beam in and out?

DR. HINCH: No. Not for --
Q Or maybe you can describe it then?
DR. HINCH: Sure. The curtains are underwater systems, so they're positioned -- you can imagine a curtain as a line of receivers interspersed evenly spaced across the sea bed --
Q Okay.
DR. HINCH: -- a certain distance apart so that they create a wall that when the transmitter goes across it, it's detected no matter where across the line it gets -- it passes. The land-based ones, that's with acoustic telemetry. It's sonar. You're listening for an underwater sound. The land-based ones are radio telemetry, where yes, you have discrete receivers in different locales in a -- and usually in a freshwater environment and those might be individual receivers, not a curtain. So they're different technologies, but used to address either a marine issue or a freshwater issue.
Q All right. What would you do or what would those responsible do with regard to that vast area out in the Gulf of Alaska? How would you arrange things to do this there?
DR. HINCH: Yes. Well, you can't effectively put lines or curtains or receivers out in the Gulf of Alaska. What you would do instead is you would have those along the coast, because the life of most of these migratory salmon is spent certainly in key times going up and down the coast. When they do go to the high seas, the information that you would be needing to collect will be from transmitters that transmit the information through satellite and so these transmitters are currently available. They're in the size now that can be affixed to maturing salmon. They've been quite big and bulky in the past. They've been used on tuna and other larger pelagic fishes and these devices are attached externally. They record information on position, latitude, longitude, temperature, depth, and then they break off of the animal, float to the top of the surface and transmit their data by satellite.
Q All right. Let me ask you a couple of questions about the Dr. Miller paper that was referred to by Mr. McDade. I'm not going to ask about the content of the paper as such, because that's going

to be addressed later in these proceedings.
Firstly, do you know Dr. Miller to go by both Dr. Miller and Dr. Miller-Saunders? Sometimes she uses a single name --

DR. HINCH: Yes.

Q -- and sometimes a double-barrelled name?

DR. HINCH: Yes. My understanding is her -- in publications it's usually just Miller, but --

Q Okay. But whether we hear Miller or Miller-Saunders --

DR. HINCH: Yes.

Q -- it's one and the same person?

DR. HINCH: It's the same person, yes.

Q Yes.

DR. HINCH: Yes.

Q And she's a DFO scientist, isn't she?

DR. HINCH: Yes.

Q And she was the lead author on that paper?

DR. HINCH: Yes.

Q And the lead researcher?

DR. HINCH: Correct.

Q And that work is ongoing?

DR. HINCH: Yes.

Q And she's a genomic scientist, correct?

DR. HINCH: Yes.

Q Now, that paper was published in January of 2011 --

DR. HINCH: Yes.

Q -- in other words, two months ago?

DR. HINCH: Yes.

Q That's Exhibit 558 and I just wonder if you could pull it up, Mr. Lunn. I'm alive and understand the paper that was marked as an exhibit but there appears to have been two parts or two documents marked and they flashed past me pretty quickly. So I've got the paper.

DR. HINCH: Yes.

Q And that's the -- as all *Science* papers are, that's the one that starts with an abstract.

DR. HINCH: Yes.

Q And is about six pages.

DR. HINCH: Correct.

Q You're familiar with that.

DR. HINCH: Yes.

Q Now, there's something else that's got itself into this exhibit.

DR. HINCH: Yes.

MR. TAYLOR: If you could bring that up, Mr. Lunn? Yes. Thank you.
Q And this appears to be -- I'm not sure how many pages, but a relatively thicker document?
DR. HINCH: Yes.
Q What is this?
DR. HINCH: This is called the supporting online material. So *Science* is a unique journal in that they only publish very small articles in terms of the number of words they'll publish. So much of the research, the nuts and bolts, the technical aspects, goes into supporting online material. It's peer-reviewed, just like the other. It's just that it doesn't appear in the journal. It appears online.
Q All right. Now, if you look at the page that Mr. Lunn has brought up here, it says published 14 January 2010. Would that be a typo?
DR. HINCH: 14 -- yes. Yes, that's incorrect.
Q Yes. And so *Science*, I think, is a reputable article but they've got themselves a year out in this particular case?
DR. HINCH: It appears they do.
Q All right. You'll agree with me then that everything here, both parts, were published in 2011?
DR. HINCH: Correct.
MR. TAYLOR: Now, Mr. Commissioner, just for your information, Dr. Miller will be here as a witness but a long time away. As we know, there will be a lot of evidence as we go through the months, and I understand she'll be here sometime in August as part of the disease section.
Now, do you want me to keep going, or take a break?
THE COMMISSIONER: It might be a convenient point to stop.
THE REGISTRAR: Hearing will now recess for 15 minutes.

(PROCEEDINGS ADJOURNED FOR AFTERNOON RECESS)
(PROCEEDINGS RECONVENED)

CROSS-EXAMINATION BY MR. TAYLOR, continuing:

Q Thank you. Dr. Hinch, I found a couple more questions about Dr. Miller's paper over the break. This genomic work is new stuff, isn't it?

DR. HINCH: Yes.
Q And I recognize you're not the genomic scientist on this, but you've been around the paper, and Mr. McDade was asking you some questions. Is it, to your knowledge, the case that all living organisms will carry with them an imprint of viral pathogens?
DR. HINCH: I can't answer that.
Q All right. It's just not your area, I take it?
DR. HINCH: It's just not my area, no.
Q Okay. Do you know whether the work that's being undertaken in this regard is going to be very long-term work?
DR. HINCH: In terms of doing more telemetry, or in pursuing --
Q No, the Miller work, the genomic stuff.
DR. HINCH: Yes. My understanding is that the intent is to make it long term. The funding to allow that is not clear.
Q All right. But there's a lot of work ahead in order to --
DR. HINCH: There is a --
Q -- pin things down, isn't there?
DR. HINCH: Absolutely.
Q Now, I'd like to see if we can understand some of the terms that have been used by you today. And I've heard you speak about, and it's in the statement of work that I see both Dr. Martins and Dr. Hinch have been given in terms of defining the work that you've done, there is reference to climate variation and climate change. And you seem to be using those terms interchangeably in your paper; is that a fair assessment on my part?
DR. MARTINS: I think when you're talking about climate change, it's just describing a change of the mean state of the climate at some point and that occurs at a long term, but overlaid over these trends and change in the mean state of the system, you also have a lot of variability and some of these variability can be, as Scott mentioned, at a decadal scale every 20 years, and also inter-annual scale, every one, two or three years.
Q I have heard it said that climate variation can refer to a shorter term series of events, or event, including oscillation back and forth, and climate change would refer more to a longer-term persistent trend one way or the other. Is that

something that accords with your understanding, or no?
DR. MARTINS: Yeah, I think one of the documents we were given is the IPCC Report. It has a pretty good definition of what climate change is. And I think it's pretty close to what you just have said.
Q All right. So are you agreeing with me that there is --
DR. MARTINS: Yes.
Q -- a distinction between variation and change?
DR. MARTINS: Yes.
Q All right. Variation being a shorter term phenomenon than change, which is longer term?
DR. MARTINS: Variation could be in the short term, like every few years. It could be what you would say, every 10, 20 years, and there is also some change that occur at centennial and millennial scales.
Q Now, in your paper, and, in particular, at page 27, you refer to the Pacific decadal, and I'll mispronounce that, oscillation, and you say something of what it is there, but can you just give me a bit more of a description? What is that and what are the indicia of it?
DR. MARTINS: What is what? What's the last question?
Q What is Pacific decadal oscillation and what are the indicia or the elements, or what --
DR. MARTINS: Okay.
A -- what's part of it, and I think we've got --
DR. MARTINS: Yeah.
Q -- page 27 up on the screen now to assist you.
DR. MARTINS: Yeah. So the Pacific decadal oscillation is a change in the mean state of the climate that occur every 10 or 20 years. The causes of the Pacific decadal oscillation, as far as I know, I'm not a climate scientist, but as far as I know, it's not understood, fully understood to this point.

We know of some general patterns. So as you can read, here, the PDO has two phase. One is called the positive phase, or the warm phase, and the negative phase, or the cool phase.

During the warm phase, you have warm sea surface temperatures in the eastern part of the Pacific Ocean, and cool temperatures in the western part. And during the negative phase, you

have the opposite pattern. And these usually persist for -- these patterns usually persist for 10 to 30 years, in some cases.

Q All right. So cool and negative go together in our part of the Pacific Ocean, and warm and positive go together in our part, do they?

DR. MARTINS: Well, warm and positive are just the same thing.

Q Right.

DR. MARTINS: And cool and negative are also the same thing. They just use different terms.

Q But did I hear you say that in the western part of the Pacific --

DR. MARTINS: Yeah.

Q -- towards Asia --

DR. MARTINS: Yeah.

Q -- the positive would have a cool?

DR. MARTINS: Yeah.

Q Okay.

DR. MARTINS: And warm in the eastern Pacific, close to where we are.

Q Yeah. Now, here in the B.C. Coast, am I correct that we're in warm phase, just coming out of a warm phase, actually?

DR. MARTINS: I can't remember exactly the phase we are right now. I know that during over the past two decades, there has been some more frequent change in the state of the PDO.

Q Okay.

DR. MARTINS: They're occurring at a more high frequency than they used to occur in the past century.

Q Do you know, Dr. Hinch, whether we're in a warm or cool phase right now, here?

DR. HINCH: I don't know about this year what we're in, but I agree with Dr. Martins that the variability has been much higher in recent years, going in and out of the high and low.

Q And temperature, and you call it warm or cool, is one of the elements or indicia. Are there other indicia to the PDO?

DR. MARTINS: I think there's also change in the pressure of the surface of the ocean but I don't understand this really well.

DR. HINCH: I can probably explain that.

DR. MARTINS: Yeah.

DR. HINCH: I mean, the PDO is one of several indices

that looks at these broad scale, long-term climate fluctuations in the ocean. One that's very similar to that is called the Aleutian Low Pressure Index and it's perhaps a bit easier to understand. It co-varies with the PDO. And as the name suggests, it has to do with a low-pressure weather system that exists over the centre of the Aleutians and what's important about low pressure is that when you have these weather systems that are one's low and one's high somewhere nearby, it's the difference between the low and high pressure that creates winds. And the more intense winds that you have occur when you have these low and high pressure systems farther apart from one another. And when you have these systems farther apart from one another and you have more intense winds, you have higher velocities of the surface water currents and that creates a phenomenon known as upwelling. And so you bring, in intense years of this index, you have a lot more nutrients being brought to the surface and cooler water temperatures at the same time. And so what you find with these 10, 20-year oscillation patterns is they are not just related to temperature, but they're also related to nutrients and food availability that are going hand in hand.

Q And does that affect the Strait of Georgia, as well, or simply the open ocean?

DR. HINCH: It's more the open ocean, but it seems to be occurring, in many cases, in sync with the decadal oscillation.

Q I think I've understood or been told that although it is more with the open ocean, there would be a flow-through effect, if you like --

DR. HINCH: Yes.

Q -- into Georgia Strait?

DR. HINCH: Yes.

Q Perhaps not as great or significant, but nonetheless, still some effect coming into Georgia Strait from this upwelling that you described. Do you know that to be so?

DR. HINCH: Yeah, in fact, I think we mentioned in our report that some of the warming of the coastal, southern B.C. coastal areas in recent years has been attributed in many ways to that, the PDO, to the fact that there's these larger-scale open

ocean processes. They do have some influence on the coast.
Q Do you know whether that played a role or was a factor at play in Georgia Strait in either or both 2007 or 2008?
DR. HINCH: Yeah, again, the details are going to be in that Skip McKinnell report that is to come later.
DR. MARTINS: As far as I know, the climate variability that was responsible for some of the change that were observed in 2007 were related to an El Niño that occurred at the end of 2006, beginning of 2007. That's what's -- it's in that report.
Q All right. I understand that in 2007, the situation was at that time, we were at the tail end of an El Niño?
DR. MARTINS: Yeah. Mm-hmm.
Q All right. And headed towards a La Nina -- La Niño?
DR. MARTINS: La Nina.
Q La Nina. Thank you. I further understand, though, that in 2007, the situation in terms of Georgia Strait and the currents and the upwellings and nutrients that were at play then were largely neutral, there was nothing dramatic happening?
DR. MARTINS: Mm-hmm.
Q Do you know that to be so, or not?
DR. MARTINS: Yeah, that's what they discuss in the report and, actually, the change -- the unusual changes that they observed were closer to the Queen Charlotte Islands.
Q Okay. And then in Georgia Strait, in 2008 --
MR. McGOWAN: Sorry, I don't want to interrupt my friend, Mr. Commissioner, but it seems to me that what's happening is that instead of relying on the witness's experience or own information, he's simply eliciting information from one of the other reports that are yet to come. I'm not sure how helpful that is, and I'll just perhaps leave him with that comment.
MR. TAYLOR:
Q Well, I'm almost done with this part, but I'll ask the question open ended, if you like. Do you know what -- I'm speaking now of 2008, do you know what was the food abundance situation in Georgia Strait coming from the climatic factors of the kind we've been discussing?
DR. MARTINS: I don't know about the food situation. I

know temperatures in the Strait of Georgia, they were above the historic, but were not very high, but outside the Strait of Georgia, they were much cooler than historic.

Q Okay. All right. Well, we'll leave that part there, I think. Now, you've given quite a bit of evidence about temperature, water temperature, and most of it, as I've heard you, has to do with the Lower Fraser River and as I understand your evidence, that there's been, in recent decades, about a one-degree increase over decades before that, and in particular, there's the chart at page 89 or 92 of your report, the blue and the red one that you're nodding your head you're familiar with.

When you move out into the marine environment, has there been a change of temperature over time? In other words, is the temperature now, on average, increasing in the marine environment as opposed to many decades earlier, or not?

DR. MARTINS: There are some published trends. IPCC mentioned about this. They report a trend of .25 degrees per decade for the North Pacific Ocean. The problem with detecting trends in marine environment is that the effect of the PDO and sometimes the El Niños are really strong so IPCC, in their report, attributes these long-term increases in temperature mostly to the warm phase of the PDO from late '70s to late '90s.

Q All right.

DR. HINCH: And the scale of warming is not as high as it was in freshwater.

Q All right. Thank you. That's helpful. As I read your report, the conclusions that you reach and your comments on mortality vis-à-vis temperature, as I read your report, your conclusions are largely of a qualitative nature as distinct from any direct causal link that you've been able to point to?

DR. HINCH: Yes, for the stages except the adults.

Q Yeah.

DR. HINCH: The adult stages, we're looking at causal links.

Q Okay. Thank you. Now, are you familiar with regional climate models that exist?

DR. HINCH: Some of them.

Q And Environment Canada is one source of those, is it?
DR. HINCH: Yes.
Q Did you have regard and look at those in the work that you were doing to prepare the paper that's now before us?
DR. MARTINS: Well, we look at some papers from some authors that have used some of these models. We haven't used these models, we are not qualified to be working with those kind of models. We don't understand them. So we're basically getting the output of what the authors of some of the papers are giving the reports and using their estimates to make our case.
Q Is it your understanding that you can look to these regional climate models, and Environment Canada's one source, but not the only source, to develop a regional or local understanding of climate factors and their impact on any number of things, including water temperature?
DR. MARTINS: If it's my understanding I can do that?
Q Yeah.
DR. MARTINS: No, I didn't know that.
Q Okay. Do you know anything about that, Dr. Hinch?
DR. HINCH: Did I know that you can use these models to make inferences about freshwater systems? Sorry, is that paraphrasing your question?
Q More or less, yes.
DR. HINCH: Yes, I mean, we can use models like that. We have used models like that for the adult stage, to make predictions about what would happen there, and these were models that DFO developed through their Environmental Watch Program, in collaboration with the Canadian Climate Centre and other schools. So there is a environmental predictions model for the Fraser that specifically looks at summer temperatures and predictions into the future. And that was the one we were relying on mostly for the adult work.
Q Now, there is a chart in your paper where -- it's the chart that has the sort of moon shape and it's got Chilko with almost no impact.
DR. HINCH: Right.
Q Just in fairness to you, it's up on the screen now, that's Chart 2.7.
DR. HINCH: It's not that Chilko doesn't have an impact, these are number of years where en route

loss is greater than 50 percent. There is en route loss occurring --

Q Yeah.

DR. HINCH: -- it's just that it's at a lower level in terms of number of years for Chilko and Quesnel, yeah.

Q Yeah. Now, I understand that the mid-summer stocks, the Sockeye stocks are the stocks that drove the 2009 return down and, conversely, drove the 2010 returns up. Are you familiar with that?

DR. HINCH: I am familiar, but I don't know if I could say much more than what you just said.

Q But although your chart shows very little mortality for the Summer runs, that chart is not indicative or showing us anything about 2009 or 2010, it seems?

DR. HINCH: No, it only goes up to 2008.

Q Yeah, okay. Well, that's a good point, but it appears from that that the fact this chart shows that there isn't that much mortality in the Summer runs doesn't jive with what, in fact, happened in 2009 or 2010?

DR. HINCH: Well, again, it's not saying that there wasn't much occurring. This is looking at the number of years in which loss was greater than 50 percent so you could have had a significant loss in one year and the bar would be just at one.

Q Okay. And correspondingly, if you look at the end points, which is the Early runs and the Late runs, they seem to have, up to 2008, many year where they have high mortality, and yet it's my understanding that those are not stocks that impacted the 2009 or 2010 results?

DR. HINCH: Yeah, they were much smaller in abundance.

Q All right. Now, it seems to me important that if one wanted to look at the impact of climate change, one would want to look at Sockeye populations other than the Fraser Sockeye and look at fish specie other than Sockeye and even beyond salmon. Now, it may be because of the terms of reference that you were given for your work, but I don't see any of that in your paper. Do you agree with me that in order to have a good understanding of the impact of climate factors, one should look at quite a number of species and what we have here in this paper is just, if you like, a snippet or a small window of what's out there?

DR. HINCH: It's a Sockeye-centric perspective, but we certainly do, when we're discussing the work in the paper, draw on other salmonid studies. You'd really want to focus on salmonids, so fish in the family salmonidae that are migrating like Sockeye, because of the similar life history characteristics. You wouldn't want to be comparing how climate change affects bass or perch because it will be different than in the way it would affect Pacific Salmon. So indeed, we focussed on Sockeye, but where we could draw an inference from other studies on other salmonids, we did.

Q And what did you conclude in that regard?

DR. HINCH: Well, a good example is the summary or the work that's been done in the Columbia system on adults. I mean, we're seeing a two-and-a-half-degree warming of the Columbia River, a much greater warming than we've seen with the Fraser, and there we are seeing dramatic declines in several stocks. Not all of them, but in many of them. And we're also seeing, though, this dramatic shift in their migration timing appears to be away from the peak temperatures, which is where we're drawing a lot of our inference from about what our stocks would have to do to persist into a warmer climate. That may be one option for them.

Q Is it not the case, though, turning to Columbia stocks, that overall, Columbia Sockeye are trending upwards?

DR. HINCH: Well, it depends on which Sockeye stock. The Okanagan Sockeye stock, in the last few years, has done quite well. The Sockeye stocks in Idaho have never been doing well, and they're the ones that travel some of the long distances.

Q So there's a mixed bag, is it?

DR. HINCH: It is, it's a complete mixed bag.

Q And I understand that the Sockeye in Bristol Bay and Alaska are trending upwards?

DR. HINCH: Yes, and so there's this latitudinal aspect, as well. And you do see this in other Pacific salmon species, as well. And with Sockeye in particular, we are at the southern range. We are at the southern range. The Columbia is the southern range, but we are very close to that and so the stocks that are in the southern range, in

general, are doing much more poorly in a Sockeye context, than those that are in the more northern latitudes.
Q Yeah. What you've just said hits on an important point, I think, and that is that we have to remember that the Fraser Sockeye are at about the most southerly extreme of what you could expect to see Sockeye at?
DR. HINCH: I agree, yes.
Q So it's something that one has to keep in mind and a little bit of climate change can have a big impact at the latitude that we're at?
DR. HINCH: That's correct.
Q At the end of the day, though, picking up on what you say in your paper and asking more generally, is it the case that it's really the Lower Fraser that we're talking about in terms of water temperature impact?
DR. HINCH: No, it's not just the Lower Fraser. That's certainly where we've spent --
A I didn't mean to exclude others --
DR. HINCH: No.
A -- but I meant to say "mainly."
DR. HINCH: It depends on the stock, and so it always comes back to stock-specific issues. In many cases, you're right, that the Lower Fraser is a critical point for many of these stocks. Especially those stocks that are coming in during peak summer temperatures and beyond temperatures. The highest ones they're getting are generally in the Lower Fraser.

On the other hand, a few of the stocks, in particular, Early Stuarts, they do encounter high temperatures early on in some years, but the temperatures get even higher for them as they migrate up the river into some of their tributaries. So in some cases, those are more unique systems and unique situations from a temperature perspective, but it's part of the variability that exists in the Fraser in terms of thermal exposure.

Q So the difference you're talking about right now is the Lower Fraser vis-à-vis the Upper Fraser, is it?
DR. HINCH: Yes. Yes.
Q And you're saying that there can still be some concerns in the Upper Fraser?

DR. HINCH: Yes.
Q Moving into the marine environment, though, as I understand it, Sockeye are quite adaptable. Georgia Strait and everything beyond that has got a fair depth to it --
DR. HINCH: Yes.
Q -- and the fish will go down to get the temperature they need; is that right?
DR. HINCH: That's what we found in freshwater systems. Up until this past year or two, we had no direct evidence of what adults or maturing adults do in the Strait of Georgia or marine areas. What we've been learning, and this is with, again, using some of this new telemetry systems, with depth sensing, temperature sensing transmitters, as we're able to see that these fish are encountering a wide range of temperatures while they're in those marine approach areas, and the temperatures would range from as cool as five or six degrees up to 16 or 18 degrees. Now, these are not temperatures that they're encountering consistently. They're encountering them in a variable fashion. Up and down, up and down the temperatures go. We don't know whether this is a behaviour that they're seeking depth and then going shallow, or whether this is the effect of river water pouring out into the marine environments and the river water tends to be warmer and they're encountering different rivers as they move through the coast. These are current research areas that we're looking at.
Q But in all of what you're saying, and I was just trying to follow that, are you agreeing, or not, that when the fish are in the marine environment, they will seek out depth --
DR. HINCH: Yes.
Q -- that will give them a temperature that suits them.
DR. HINCH: They seem to. The only other issue, though, is that depth in these marine areas is high saline water and it's often low in oxygen, or, sorry, it's high saline water that's very cool. When they're down in these areas, it's much more difficult for them to continue migrations and know where they're going. So we see this questing of behaviour, going up and down, up and down. Yes, they can receive thermal benefits in that way, and we suspect that's what's happening, but

it's too early to tell how much a benefit it is and what the cost is because they are going deep and not being able to smell their home river which is really why we think they're in the surface water so much.

Q Now, coming back to the Fraser River, itself, that's largely a uniform temperature no matter what depth you're at, isn't it?

DR. HINCH: In the lower river, yes.

Q And it almost goes without saying, but just to be clear, the Fraser system is a mountain-fed system, right?

DR. HINCH: Yes. Yes.

Q And that means that it's dependent on the snow pack?

DR. HINCH: Yes, until the snow is gone in mid to late summer, in which case, it's rainfall-dominated then.

Q Now, there's other things that temperature that come into play vis-à-vis climate, I would think.

DR. HINCH: Yes.

Q And one would be when you get spring and summer, which, in turn -- and even before that, what you've had during the winter, but you can have a snow pack that melts early or it melts late.

DR. HINCH: Yeah.

Q And that's going to have different impacts and that's going to be dependent on the climate factors, isn't it?

DR. HINCH: Yes. Yes, and we've seen this and it's been reported in these various climate reports that, particularly for the Fraser, that we now have peak discharge coming -- how many several days earlier?

DR. MARTINS: Yeah, it's likely five or six days earlier.

DR. HINCH: Five or six days earlier than in historical periods. So we are seeing that shift, what appears to be beginning now, with the volume of water peaking earlier in the late spring than it used to peak.

Q And is the case that if you have a cool spring and then it warms up eventually, whenever summer comes, and you have a quick melt, if that's occurring at the time that the spawning is occurring, you're going to have some risk of flooding and scouring, and essentially, an awful

lot of problems with --
DR. HINCH: Yeah.
Q -- eggs being damaged or destroyed?
DR. HINCH: Yeah. I think the bigger issue for Sockeye in that regard, because they tend not to be spawning in June when these freshets are happening, the bigger issue is for the Early runs, if they are suddenly encountering a much higher discharge. And high discharge can have a similar effect on their metabolism as high temperature in that if you're encountering a large volume of water, you're using a lot of energy to cross the same amount of distance. And certainly in some years, '97 and '99 are good examples for the Early Stuart, you saw a lot of en route mortality, but it was probably related more in those years to high discharge because of the phenomenon you just mentioned.
Q All right.
DR. MARTINS: Just to add, you were mentioning scouring mortality due to you're saying the snow pack melting and producing flows that would cause scour.
Q Mm-hmm.
DR. MARTINS: Actually, what's expected to occur is that because there may be more precipitation during the winter, when the eggs are incubated, and more of this precipitation may fall as rain, then you may expect an increase in flows and that increase in flows may scour eggs and cause mortality.
Q All right. Just by the way, do you know what the optimum water temperature for spawning is?
DR. HINCH: For egg incubation, I believe it's --
DR. MARTINS: Egg incubation of --
DR. HINCH: -- six to eight?
DR. MARTINS: Yeah, in the studies that we reviewed and the authors found that the highest survival of the eggs were around eight degrees.
DR. HINCH: Yeah.
Q Okay. Centigrade?
DR. MARTINS: Yes.
Q Yes.
MR. TAYLOR: I'm about 10 to 15 minutes out.
THE COMMISSIONER: Is that an accurate estimate, Mr. Taylor?
MR. TAYLOR: It's more accurate than Ms. Gaertner.

MS. GAERTNER: Oh, that's not fair. I actually take objection to that.
MR. TAYLOR: It's pretty good. I can stick to that.
THE COMMISSIONER: Why don't we go to 4:10, then.
MR. TAYLOR: I said 10 to 15.
Q All right. Let's move on. I want to ask you some questions about your recommendations, if I may. You summarized them at the beginning of your report, around page 6/7, and then you've got them set out more fully at --
MR. TAYLOR: I didn't mean for Ms. Gaertner to leave.
Q More fully at pages 54 and following. First let me ask you this, have you costed out any of those recommendations?
DR. HINCH: No, not directly.
Q Have you even looked at which of them would be the more or less expensive? That's fine if --
DR. HINCH: They're all expensive.
Q All right.
DR. HINCH: They all require us to do more than we're doing now so there's costs.
Q I was going to say that your recommendations are many and rich in detail, and they appear to be rich in price, as well.
DR. HINCH: Well, you know, it's possible, but, you know, you have to ask yourself what's the cost of not doing that work.
Q Exactly.
DR. HINCH: Yeah.
Q Net benefit and cost benefit and so forth. Have you looked at which of those recommendations give you the biggest bang for your buck in terms of scientific or factual knowledge that would come from it?
DR. HINCH: I think the most novel scientific, factual angle or aspect would come from my first recommendation. Telemetry approaches and direct experimentation are needed to better understand Sockeye salmon and marine survival.
Q From your evidence just this moment and the other evidence you've given today, that seems to resonate with me as to what you consider to be your most important or highest-priority recommendation; is that fair?
DR. HINCH: It would be the most novel, scientifically.
Q Okay. Maybe you can just explain what you mean by "novel" because I did ask you where you get the

biggest bang for your scientific buck.
DR. HINCH: Well --
Q Not buck, but biggest bang in terms of scientific or factual knowledge, and then you phrased it in terms of novel.
DR. HINCH: Yeah. Well, I guess I come back to if we're using science to inform management or policy, that's very important. If you're looking for the most novel science, and, of course, novel science, oftentimes, you don't know when it's going to inform management or policy, that's why we do novel science, eventually, or sometimes it suddenly becomes very critically important, like with Kristi Miller's work. We had no idea how important that could become.

The first one I suggest is going to be the most novel because we've never done it before. We have not done direct experimentation on most life stages of salmon, in terms of looking at their movements, their survival, their behaviourship, and how that affects -- one stage affects the other stage, one life stage transcends its affects onto another life stage.
Q All right. If you did prioritize them, and if you can do it quickly, because --
DR. HINCH: Right.
Q -- Mr. Commissioner's put me, at least, under a time gun, can you prioritize the 10 recommendations that you've got? And I don't mean for you to rank them 1 to 10, but, rather, which one or ones are the most important --
DR. HINCH: Okay.
Q -- and which ones could you see not being done, recognizing that money is a finite resource, and I sense from your answers that you recognize that not everything is going to be done.
DR. HINCH: Yes.
Q Just because you can't do everything, either logistically, or financially.
DR. HINCH: Several of these things can be done simultaneously. And so I guess if I looked at it that way, the telemetry approaches and direct experimentation, number 1, is tied in directly with number 3, improvements in in-season management and biomarkers. Those are intimately related. The one after that, tagging programs are needed. That is part of the infrastructure for

that research, so number --
Q Sorry, can you give a number?
DR. HINCH: So number 1, 3 --
Q And 4?
DR. HINCH: -- and 4 are intimately related, and then the last one that is tied directly to that is, I guess, number 9. This is the inter-generational aspects. If you want to look at one life stage, that's fine. If you want to look at how one life stage's experiences, whatever is happening to it influences the next life stage, that's what an intergenerational affect is. And so that type of research is subsumed in the telemetry and technical suggestions of 1, 3 and 4.
DR. MARTINS: I would probably say 5 and 6, as well, because you would be using the same technology.
DR. HINCH: And 5 and 6 would also be subsumed under those technological infrastructure, yes.
Q Okay.
DR. HINCH: So I don't know if I helped you --
Q I asked you to prioritize, and you started with 1 and 3 and managed to get most of them in.
DR. HINCH: Thank you. If you'd like me to think more about it and come up with a better ranking, I can do that, but it's hard for me seeing the issues we're confronted with and saying one is more valuable than another because I think so many of them are important.
Q But again, it's fair to say that telemetry and any suite of recommendations around that are what you consider to be --
DR. HINCH: Yes.
Q -- the most important?
DR. HINCH: Yes.
Q All right. I want to ask you quickly about a document that we have, the Government of Canada has put forward for use in this part of the hearings, and with any luck, you either have a binder or --
DR. HINCH: Yeah. Yes, we have it.
Q Okay. It's the first document in that binder, which --
DR. HINCH: Yeah?
Q -- says Chapter 8, I think, and Mr. Commissioner, you would have a copy, as well. Is that a document that's familiar to you?
DR. HINCH: No, it wasn't.

Q All right.
DR. HINCH: But I did read it.
Q Okay. And I'm just going to put it in front of me. I'd like you to turn to page 224 -- 244, I think it is.
DR. HINCH: Our pages aren't that numbered. They start at 3 --
Q Sorry, it's 344. Is yours different? It should be in the lower left corner, I think.
DR. HINCH: Mm-hmm?
Q Thank you. Now, what I understand this to be, it's a document that was prepared by I'm not sure exactly what organization, but you can see there's a whole list of authors. And it is a document that is a overview of climate change impacts and project climate change impacts on various sectors in the Province of British Columbia, and one of those is fisheries.
DR. HINCH: Mm-hmm.
Q If you look at page 344, you'll see that fisheries is being dealt with and it says, in the second column, near the end of the first whole paragraph in that second column:

> These relationships make it clear that climate change will induce a wide range of responses from fish and fisheries in B.C.

Now, you, in your evidence, both of you, have spoken to aspects that go to this, but do you agree with that statement, both of you? One at a time, or each of you?
DR. HINCH: I'm just trying to find the exact sentence.
DR. MARTINS: Is this the last paragraph in this second column?
Q Yeah, there's a paragraph that begins, "During the past century --
DR. HINCH: Okay.
Q -- in the second column.
DR. HINCH: Right.
DR. MARTINS: Okay.
Q And then at the end of that paragraph.
DR. HINCH: Yes, I would agree with that.
Q Dr. Martins?
DR. MARTINS: Yes.
Q And then in the next paragraph, it says:

Sensitivity to climate variability and change varies greatly between short-lived species, such as shrimp, salmon, and some others, and others who live longer.

Do you agree with that statement?

DR. HINCH: Yes.

Q All right.

DR. MARTINS: Yes.

Q Sorry, Dr. Martins?

DR. MARTINS: Yes.

Q Okay.

MR. TAYLOR: I'd ask that this document, which is called Chapter 8, British Columbia, and it's not in the title, but it is an overview of climate change factors, I'd ask that that be an exhibit, please.

THE REGISTRAR: Exhibit number 560.

EXHIBIT 560: Chapter 8, British Columbia (overview of climate change factors)

MR. TAYLOR: And with that, those are my questions. Thank you.

THE COMMISSIONER: It's 4:08. Mr. McGowan, who is up next, in the morning?

MR. McGOWAN: Mr. Commissioner, the Province will be the next participant examining tomorrow, followed, I believe, by counsel for Rio Tinto and Mr. Blair for the salmon farmers.

THE COMMISSIONER: Thank you very much and thank you, again, Mr. Taylor, for your efficiency.

THE REGISTRAR: The hearing is now adjourned until 10 o'clock tomorrow morning.

(PROCEEDINGS ADJOURNED TO MARCH 9, 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.

_____

Karen Hefferland

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.

_____

Irene Lim