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.

Wednesday, August 24, 2011

Tenue à :

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

le mercredi 24 août 2011

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into the Decline of
Sockeye Salmon in the Fraser River

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de saumon rouge du fleuve Fraser

Errata for the Transcript of Hearings on August 24, 2011

Page	Line	Error	Correction
ii		Appearance for the Conservation Coalition	Judah Harrison also attended as counsel

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APPEARANCES / COMPARUTIONS

Brock Martland Jennifer Chan Kathy L. Grant	Associate Commission Counsel Junior Commission Counsel Junior Commission Counsel
Mitchell Taylor, Q.C. Jonah Spiegelman	Government of Canada ("CAN")
Clifton Prowse, Q.C. Tara Callan	Province of British Columbia ("BCPROV")
No appearance	Pacific Salmon Commission ("PSC")
Chris Buchanan	B.C. Public Service Alliance of Canada Union of Environment Workers B.C. ("BCPSAC")
Matt Keen	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 Foundation ("CONSERV")
Don Rosenbloom Katrina Pacey	Area D Salmon Gillnet Association; Area B Harvest Committee (Seine) ("GILLFSC")

APPEARANCES / COMPARUTIONS, cont'd.

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

APPEARANCES / COMPARUTIONS, cont'd.

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

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1 Vancouver, B.C./Vancouver
2 (C.-B.)
3 August 24, 2011/le 24 août
4 2011
5
6 MS. CHAN: Mr. Commissioner, Jennifer Chan appearing
7 for the Commission, and with me is Brock Martland
8 and Kathy Grant. Today, we begin our second panel
9 on the topic of disease. Our witnesses are Dr.
10 Kristina Miller and Dr. Kyle Garver. If I could
11 have the witnesses sworn or affirmed, please.
12
13 KRISTI MILLER, affirmed.
14
15 KYLE GARVER, affirmed.
16
17 THE REGISTRAR: Would you state your name, please?
18 DR. MILLER: Kristi Miller.
19 THE REGISTRAR: Thank you.
20 DR. GARVER: Kyle Garver.
21 THE REGISTRAR: Thank you. Counsel?
22 MS. CHAN: Mr. Commissioner, after an introduction,
23 I'll be seeking to qualify Dr. Miller as an expert
24 in molecular genetics, immunogenetics and
25 functional genomics, with a specialty in salmon.
26 If I could have Tab 16 of the Commission's list
27 up, please?
28
29 EXAMINATION IN CHIEF ON QUALIFICATIONS BY MS. CHAN:
30
31 Q Dr. Miller, do you recognize this document as your
32 c.v.?
33 DR. MILLER: Yes.
34 MS. CHAN: Could I have that marked as an exhibit,
35 please?
36 THE REGISTRAR: Exhibit number 1510.
37
38 EXHIBIT 1510: *Curriculum vitae* of Dr. Kristi
39 Miller
40
41 MS. CHAN:
42 Q Dr. Miller, you're the head of the Molecular
43 Genetics Section of the Salmon and Freshwater
44 Ecosystems Division of DFO's Pacific Region
45 Science Branch; is that right?
46 DR. MILLER: That’s correct.
47 Q You're also an adjunct professor with the

1 Department of Forest Sciences at UBC?
2 DR. MILLER: Correct.
3 Q And you have a Ph.D. in biological sciences from
4 Stanford University, obtained in 1992, and M.Sc.
5 in zoology from UBC obtained in 1986, and a B.Sc.
6 in biology from the University of California Davis
7 in 1983?
8 DR. MILLER: Correct.
9 Q Your research interests include molecular
10 population genetics of aquatic organisms,
11 conservation genomics, salmon migration
12 physiology, adaptive immunity and host responses
13 to pathogens?
14 DR. MILLER: Yes.
15 Q And you're also the lead author of an article
16 published in the *Journal of Science* in January
17 2011, entitled, "Genomic signatures predict
18 migration in spawning failure in wild Canadian
19 salmon," is that right?
20 DR. MILLER: I am.
21 MS. CHAN: And Mr. Commissioner, that paper is an
22 exhibit at Exhibit 558.
23 Q Dr. Miller, would you consider yourself an expert
24 in virology?
25 DR. MILLER: No.
26 MS. CHAN: And subject to any further questions, if I
27 could ask that Dr. Miller be qualified as an
28 expert in molecular genetics, immunogenetics and
29 functional genomics, with a specialty in salmon?
30 THE COMMISSIONER: Yes, thank you, Ms. Chan.
31 MS. CHAN: And now to Dr. Garver. I'll be seeking to
32 qualify Dr. Garver as an expert in molecular
33 virology with a specialty in viruses affecting
34 salmon. If we could have Tab 17 up, please?
35 Q Dr. Garver, do you recognize this document as your
36 *CV*?
37 DR. GARVER: Yes, I do.
38 MS. CHAN: If I could have that marked as the next
39 exhibit, please?
40 THE REGISTRAR: Exhibit 1511.
41
42 EXHIBIT 1511: *Curriculum vitae* of Dr. Kyle
43 Garver
44
45 MS. CHAN:
46 Q Dr. Garver, you lead the Virology Research Program
47 of the Aquatic Animal Health Section and that's in

1 the Salmon and Freshwater Ecosystems Division of
2 DFO's Pacific Region Science Branch; is that
3 right?
4 DR. GARVER: That’s correct.
5 Q You hold a Ph.D. in molecular virology from Purdue
6 University, obtained in 2000, a B.Sc. in biology
7 from Pennsylvania State University in 1993; is
8 that right?
9 DR. GARVER: That’s correct.
10 Q And your research interests include various
11 aquatic viruses, including viral hemorrhagic
12 septicaemia virus, infectious hematopoietic
13 necrosis virus, and koi herpes virus?
14 DR. GARVER: That’s correct, I specialize mostly in fin
15 fish.
16 Q And among other things, you're currently
17 conducting research on a virus hypothesized to be
18 associated with Dr. Miller's mortality related
19 signature?
20 DR. GARVER: That’s correct.
21 MS. CHAN: So subject to any further questions, I'd ask
22 if Dr. Garver could be qualified as expert in
23 molecular virology, with a speciality in viruses
24 affecting salmon.
25 THE COMMISSIONER: Yes, thank you, Ms. Chan.
26 MS. CHAN: If we could start with Tab 18 of the
27 Commission's documents, please, that's Exhibit
28 558.
29
30 EXAMINATION IN CHIEF BY MS. CHAN:
31
32 Q And Dr. Miller, do you recognize this as a science
33 article that you published in 2011 in the *Journal*
34 *of Science*?
35 DR. MILLER: Yes, I do.
36 Q Now, I understand that not all journals are
37 regarded equally. How does the *Journal of Science*
38 rank in comparison to others?
39 DR. MILLER: It ranks about the same as *Nature*. It's
40 one of the top two leading journals in the world.
41 Q And Dr. Scott Hinch is a co-author, I see, on the
42 third line, there, in the list of authors. He
43 testified earlier on some of the biotelemetry
44 aspects of the paper. And I'll be asking you
45 about some of the conclusions that you've reached,
46 but before I do, I just want to, for the purposes
47 of our discussion today, canvass with you my

1 understanding of some of the technology and
2 methods used and see if you agree with my
3 understanding. So first of all, the microarray of
4 technology that you used, first of all, you used
5 microarray technology for this paper?
6 DR. MILLER: Yes, correct.
7 Q And this is a tool that allows you to take a
8 tissue sample, looks at tens of thousands of genes
9 in that sample all at once to see which genes are
10 turned on and which genes are turned off; is that
11 right?
12 DR. MILLER: Yes.
13 Q Now, by looking at these genes and which ones are
14 turned on and turned off, you may gain information
15 about the physiological condition of the tissue
16 being tested?
17 DR. MILLER: Yes.
18 Q And that condition may express as a pattern,
19 sometimes referred to as genomic profile or a
20 genomic signature?
21 DR. MILLER: Yes.
22 Q Okay. So that's the microarray technology. If we
23 could see if you agree with my understanding of
24 the method here. Now, members of your team, so
25 there's the authors listed on the front of that
26 paper, there, captured and tagged fish in the
27 ocean, in the river, at the spawning grounds, and
28 then took samples of the gill tissue from that
29 fish; is that right?
30 DR. MILLER: Yes, non-destructive samples of the gill
31 tissue.
32 Q So the fish didn't die?
33 DR. MILLER: No, and there's been quite a few studies
34 that Scott Hinch and Tony Farrell's group had done
35 previous to this study to show that there was a
36 very minimal impact on survivorship of taking
37 tissue samples, gill tissue samples from these
38 fish.
39 Q And then you took that gill tissue and you tested
40 it using the genomic microarray that we just
41 discussed; is that right?
42 DR. MILLER: Yes.
43 Q And you also used biotelemetry, that Dr. Hinch
44 described to us when he was here, to see which
45 fish made it to the spawning grounds and which
46 ones successfully spawned?
47 DR. MILLER: Yes, and importantly, we also ran genetic

1 stock ID on all of those fish so that we knew
2 where they were going when they were migrating and
3 we could look at stock-specific differences.
4 Q So when you compared the migration and spawning
5 information from the biotelemetry to the
6 microarray information from the gill tissue, what
7 did you find?
8 DR. MILLER: Well, we basically were able to contrast
9 the genomics of the fish that made it to the
10 spawning ground successfully, or in the case of
11 the study at the spawning grounds, the fish that
12 were successfully spawned with those that were
13 unsuccessful, either in terms of their migration
14 or their spawning. And in doing so, we found that
15 in all three of our independent tagging studies,
16 that the same genomic signature was associated
17 with poor success no matter whether the fish were
18 tagged in the marine environment about 200
19 kilometres before they enter the river, whether
20 they were tagged in the lower river, or whether
21 they were tagged at the spawning grounds. The
22 same signal was emanating from the data.
23 Q So this signal, and I also heard you say the word,
24 "genomic signature," is this the same as the
25 mortality-related signature that we've seen?
26 DR. MILLER: Yes. Yes, that is what we have termed the
27 mortality-related signature. And in the marine
28 environment, when fish carry that signature, they
29 had 13.5 times lower probability of making it to
30 the spawning grounds and that was also seen,
31 although it was not as high a difference in
32 probability in the lower river and, again, at the
33 spawning grounds.
34 Q Now, this paper, if I understand correctly, looked
35 at 2006 returning adults; is that right?
36 DR. MILLER: Yes, it did.
37 Q Beyond this paper, have you looked at the
38 mortality-related signature, which I'll call MRS,
39 in other years of returning fish, or in other
40 tissues, or --
41 DR. MILLER: We have. It's unusual to be able to have
42 this tagging program and that only happens when
43 there's a lot of fish coming back. We are
44 actually conducting a study that basically is a
45 mirror of this, only with even more fish from fish
46 that were tagged in 2010. But we have conducted
47 quite a large number of studies using

1 destructively sampled tissues. We have profiled
2 liver tissue, brain tissue, gill tissue in other
3 studies, as well, and muscle tissue, white muscle
4 tissue, and we've also looked at hypothalamus, as
5 well. Our studies date back all the way to 2003
6 returning adults. Most of these studies don't
7 have the contrast between successful and
8 unsuccessful fish because we don't have radio
9 tracking and with these other tissues, we can't
10 sample a liver tissue or brain tissue not
11 destructively so you can't directly relate any
12 kind of fate with the signatures that you see,
13 but, yes, we have looked at other tissues and one
14 of the findings that we made after we had done
15 this particular study was that we were observing
16 this same signature, this mortality-related
17 signature in other tissues, as well.
18 Q So you have this additional information on the
19 mortality-related signature in other tissues and
20 you said also for other returning years and other
21 lifecycles?
22 DR. MILLER: Yes, in 2005, we profiled gill, liver and
23 brain tissue in all the same fish, and we observed
24 the mortality-related signature in each of those
25 tissues, but interestingly, very different
26 prevalence rates in different tissues and
27 individuals didn't necessarily contain that
28 signature in all tissues. In fact, it was more
29 common for them to contain the signature in only
30 one or two tissues.
31 Q With this additional information, and we've heard
32 that the DFO and PSC keeps records of sockeye
33 migration success and sockeye spawning success,
34 have you been able to compare your tests looking
35 at the MRS prevalence to the success of migration
36 and spawning from those data?
37 DR. MILLER: We have the fish, certainly, to do that,
38 not to do direct comparisons. We don't have the
39 fish that are from radio-tracking programs, where
40 we can compare success versus lack of success, but
41 we have samples. We have adult fish that have
42 been collected all the way back to 2003 and,
43 basically, virtually every year since then. And
44 so what we have not done, microarrays are very
45 expensive to run, they are about $400 an
46 individual to run so we are moving towards a new
47 technology that is faster and cheaper and where we

1 can run through thousands of fish and simply score
2 them, do they carry the MRS signature, or not, and
3 that's a technology that we're employing now in
4 our lab. And we will be running through,
5 basically, our whole archive of about 2,500
6 samples that have been collected since 2003 and so
7 we will have a better feel for that because we're
8 interested now in the prevalence of the signature
9 across multiple tissues now that we have
10 discovered that it isn't simply in gill tissue.
11 Q Okay. So it sounds like you're working on the
12 technology to scan for the MRS prevalence in a
13 more efficient way, but looking at the MRS
14 scanning technique that you've used in the past,
15 the genomic microarray, have you seen a
16 correlation between the MRS prevalence in the
17 samples that you've already looked at to returning
18 fish, for example?
19 DR. MILLER: You mean to pre-spawning or en-route
20 mortality?
21 Q To en-route mortality or pre-spawn mortality, or
22 even the numbers returning from the ocean, have
23 you seen any correlations between MRS prevalence
24 and sockeye survival?
25 DR. MILLER: Well, we've done a lot of work on 2005,
26 and that would have been the brood year for the
27 2009 returns. And those fish carried, if you
28 added up the prevalence of that signature in each
29 of the different tissues, or the presence of that
30 signature in each of the different tissues, that
31 was gill, liver, brain, that we surveyed, the
32 overall prevalence would have been 75 percent of
33 the fish contained that signature in at least one
34 tissue. And that was really pretty high compared
35 to other years that we had looked at, but there
36 wasn't any other years that we had looked at that
37 same suite of tissues, and that's why this faster
38 technology's going to be very valuable, because I
39 really do believe that it isn't simply that it's
40 present in one tissue, but how many tissues is it
41 present in?
42 Q So just to check that I heard you correctly, the
43 brood year of 2005 fish, you found over 75 percent
44 prevalence of the MRS signature in at least one
45 tissue?
46 DR. MILLER: Correct, a fairly low prevalence rate in
47 gill tissue, however, compared to 2006.

1 MS. CHAN: I wonder if we could turn to the
2 Commission's Tab 22, please?
3 Q Dr. Miller, do you recognize this document? I
4 understand it's something that you might have
5 created?
6 DR. MILLER: Yes.
7 Q And can you give us any of the contextual
8 background for this document? Where was it made,
9 when was it presented, to whom?
10 DR. MILLER: I believe this is the document that was
11 prepared for the Pacific Salmon Commission
12 meeting, which was in 2010, I believe, in June of
13 2010, and so we were asked, a number of scientists
14 were asked by the Commission to present their
15 unique hypotheses and the data that they had in
16 support of those hypotheses being an impact on the
17 salmon returns.
18 MS. CHAN: If I could have this marked as the next
19 exhibit, please?
20 THE REGISTRAR: Exhibit 1512.
21
22 EXHIBIT 1512: Hypothesis prepared for
23 Pacific Salmon Commission meeting, June 2010
24
25 MS. CHAN:
26 Q Now, if we go down to the bottom of the first
27 page, and it's the second bullet from the top, it
28 reads:
29
30 In 2008, 60% of smolts left the Fraser River
31 with the unhealthy signature in brain, 40% in
32 liver, with 82% of fish affected in at least
33 one tissue. There was a 30% reduction in
34 brain prevalence of unhealthy signature fish
35 from summer to fall in the ocean, and a 50%
36 reduction in liver.
37
38 I'm just going to jump to the last bullet, there,
39 on the bottom:
40
41 If these decreases in prevalence were due to
42 mortality, and if we assumed that 120 million
43 smolts left the river in 2008 (there may have
44 been more), we could account for the loss of
45 more than 27 million salmon in 2008
46 associated with the unhealthy signature
47 alone.

1 Now, the smolts that left in 2008, when would they
2 have returned?
3 DR. MILLER: In 2010.
4 Q So just picking up on your comment earlier about
5 the 2005 brood year fish coming back in 2009, with
6 75 percent MRS positives, in these fish --
7 DR. MILLER: That's adults.
8 Q Okay. So that's as adults?
9 DR. MILLER: That's in returning adults.
10 Q Okay. So this one, here, is looking at smolts?
11 DR. MILLER: This is smolts. This is smolts leaving
12 the river.
13 Q Okay. 82 percent of smolts having the MRS
14 positive signature, is that a high percentage?
15 DR. MILLER: In 2008 was the first year that we had
16 done any smolt studies and so we didn't have a
17 benchmark for smolts. 2008 was really the year
18 that our program on smolts starts and so we only
19 had a very small number of 2007 fish, which I'm
20 sure we'll come into later. What we have observed
21 with this signature is that the highest prevalence
22 that we observe in any of the tissues occurs
23 before fish leave the river. And so we always
24 see, and we are accumulating more years of data on
25 this, but we have observed that we can see very
26 high prevalences of this signature, but very
27 variable among different years, of fish leaving
28 the river. The fish that return, we still see the
29 signature in some portion of the adults that
30 return. In the two years where we have any data,
31 the proportion of adults affected is much less
32 than what we see of smolts leaving the river with.
33 Q Okay. So but 82 percent of smolts leaving the
34 river with the MRS positive, would that have
35 predicted mortality, or would that be considered
36 normal?
37 DR. MILLER: 82 percent of the fish leaving the river
38 with at least one tissue affected, we don't have a
39 way to directly assess mortality and this is why
40 we're just looking at shifts in the prevalence of
41 this signature. If you contrast what we observed
42 in 2007, which is really the only other piece of
43 data we had on this signature at the time, it was
44 after this study, one thing that is really highly
45 different between them is that most of these
46 smolts that carried this signature, only 20
47 percent of these fish carried the signature in

1 both tissues, okay? And in 2007, virtually all of
2 the fish carried the signature in both tissues.
3 So I think it's a difference in the intensity of
4 the signature, in that it's carried across
5 multiple tissues. And it was virtually, again,
6 sample sizes, and we can get into 2007, were very
7 small, there were very few fish available to us,
8 but a fish leaving the river, 10 out 10 for both
9 brain and liver contained the signature.
10 Q In 2007?
11 DR. MILLER: In 2007.
12 Q I think we do have some of your 2007 information.
13 MS. CHAN: If we could turn to, I believe it's Tab 24
14 of the Commission's list, please?
15 Q Dr. Miller, is this a presentation that you've
16 given? Here, I'm reading the title, "Genomic
17 studies suggest that a novel disease is affecting
18 sockeye and may be an important contributor to the
19 Fraser River sockeye situation"?
20 DR. MILLER: Yes.
21 Q And who did you give this presentation to?
22 DR. MILLER: This was an inter-departmental meeting,
23 intra-departmental meeting that was really aimed
24 to provide more information from whatever was
25 presented at the Pacific Salmon Commission meeting
26 so it was an update meeting for the Department.
27 MS. CHAN: Okay. If I could have this marked as the
28 next exhibit, please?
29 THE REGISTRAR: Exhibit 1513:
30
31 EXHIBIT 1513: Presentation entitled,
32 "Genomic studies suggest that a novel disease
33 is affecting sockeye and may be an important
34 contributor to the Fraser River sockeye
35 situation"
36
37 MS. CHAN:
38 Q And I want to bring you to slide number 6, and I
39 think we can use that to follow up on the 2007
40 data that you were just describing. Is this slide
41 the one that you were referring to, or that you
42 were discussing the 2007 data?
43 DR. MILLER: This is a slide that refers to the
44 contrast between 2007 and 2008. These fish were
45 only fish that were sampled in the marine
46 environment, in the end of June, around the same
47 week in both years, yes.

1 Q And what does it mean when it says there that:
2
3 90% prevalence of MRS fish late June in the
4 ocean in 2007
5
6 And:
7
8 40% prevalence of MRS fish late June in the
9 ocean in 2008
10
11 DR. MILLER: We work with the bioinformatics group at
12 the University of British Columbia, led by Paul
13 Pavlidis, and we've discovered that we can
14 identify this signature quite readily as using
15 principled component analysis. And in general, it
16 comes up as explaining the largest source of
17 genomic variation among individual fish and so
18 this shows the ranking for principle component
19 analysis and here, the MRS signature are the
20 individuals that rank negatively with principle
21 component 1. And so what this shows is that of
22 the 10 2007 fish that were sampled, nine out of 10
23 of those in the ocean at the end of June contained
24 this signature. If you compare that with 2008,
25 with fish that are sampled around the same time,
26 it's a much lower percentage, it's somewhere
27 around 40 percent.
28 Q What does that tell us about predicting returns
29 for 2009 and 2010?
30 DR. MILLER: Well, that's something that we're still
31 studying, right? So understanding the
32 predictability with the smolt signature, because
33 we don’t have the ability to directly contrast,
34 you know, the successful and unsuccessful
35 individuals, we are, right now, trying to gather
36 information about prevalence, and that kind of
37 information needs to be gathered over a number of
38 years of study where we know what the outcomes
39 were. And so this highlights the first study
40 where we show that this signature does exist in
41 smolts, that it is in quite different levels of
42 prevalence in these two years, with the caveat
43 that it's a very small sample size for 2007. And
44 so I would say I don't know that we understand
45 completely how predictable this is at this point
46 in smolts. This is where our research is going.
47 But I can say that, you know, if we look at Chilko

1 fish, where we have a lot of data about Chilko
2 because they're a very large stock and it's very
3 easy to pick those up in the ocean environment, we
4 do see very dramatic differences in the prevalence
5 of this signature in the summer in the ocean. And
6 where we're looking to go is to establish whether
7 or not it's simply the prevalence of the signature
8 in the ocean, or whether it's the shift in
9 prevalence that we observe over time that's more
10 important in terms of being a predictor.
11 Q And in terms of the fish going out into the ocean
12 and the shifting of prevalence, have you done any
13 investigations about the ocean environmental, or
14 other environmental conditions and looked to see
15 whether or not those affect the MRS prevalence?
16 DR. MILLER: I'm working with colleagues at DFO, with
17 Mark Trudel and Dick Beamish, and more recently,
18 with the PARR program, getting samples earlier in
19 the year, and we do collect data on these
20 individual fish on other parameters, like whether
21 they were feeding, or not, and what the ocean
22 conditions were like when they were captured, but
23 we need to get enough years of data to start to
24 pull those together, and I have a post-doc who
25 will be modelling these relationships because I do
26 feel that there's a very high probability, if this
27 is important in the early marine environment, that
28 it probably has to be seen in the context of the
29 overall environmental conditions that are present
30 there.
31 Q And understanding that your work is ongoing in
32 this area, have you had any indication to tell you
33 whether or not the MRS prevalence is more of a
34 determinant factor relative to ocean conditions or
35 whether or not environmental factors play a
36 greater or larger role?
37 DR. MILLER: My speculation is that what will be the
38 best predictor will be the shift in prevalence
39 that we observe between fish that leave the
40 freshwater environment and fish sampled in the
41 ocean, and that that shift may reflect the
42 differences in the ocean environment in different
43 years and how survivable it is for fish. If fish
44 enter the river in poor condition and then -- or
45 into the ocean, I'm sorry, into the ocean in poor
46 condition, and then into an ocean that is
47 additionally stressed, like my colleague suggests

1 was the case in 2007, that that may have a more
2 profound effect on their survivorship than if they
3 enter the ocean in good condition, and the ocean
4 is in good conditions, like we observed in 2008.
5 Q Now, we've discussed that you've looked for this
6 MRS in other fish and other tissues. Have you
7 looked for the MRS in farm fish or in hatcheries?
8 DR. MILLER: We have begun working on -- we have coho
9 and chinook salmon, as well, collected within our
10 program, and we are working on coho salmon and we
11 have quite an extensive hatchery collection from
12 them.
13 Q Sorry, so that's the hatchery, do you have fish
14 farm fish to test for the MRS, as well?
15 DR. MILLER: We have some chinook salmon from Creative
16 Salmon for another project and we are working with
17 the industry and will be getting samples very
18 shortly.
19 Q Just to clarify, you said you have chinook salmon
20 from Creative Salmon --
21 DR. MILLER: Creative Salmon, yes.
22 Q -- for another project. Is that looking for the
23 MRS prevalence?
24 DR. MILLER: No, that project is about a jaundice
25 syndrome that has created problems with mortality
26 over winter in cultured chinook salmon, and we are
27 using genomics to try to determine whether or not
28 that syndrome is more likely to be environmentally
29 induced or due to a pathogen.
30 Q Okay. Focussing on the MRS prevalence, have any
31 Atlantic fish farms provided you with samples to
32 test for the prevalence of this MRS?
33 A Not at this time.
34 Q Have you asked for samples from fish farms, from
35 Atlantic salmon fish farms?
36 A When the paper came out in Science, I was
37 approached by Mary Ellen Walling about what this
38 meant and the potential of testing their fish, and
39 we had a discussion about that and she was going
40 to follow up and talked to the vets about it, and
41 I believe, at the time, the vets weren't
42 comfortable with testing for a signature. And
43 more recently, we have been in conversation
44 because we have identified now a candidate virus
45 associated with this signature and we have
46 approached the industry again about testing now
47 for this virus and they've agreed to do so.

1 Q Just so that the record is clear, could you tell
2 us who Mary Ellen Walling is, please?
3 DR. MILLER: She's the head of the B.C. Salmon Growers
4 Association.
5 Q Have you asked anyone at DFO to assist you in
6 obtaining samples from Atlantic salmon farms for
7 the purpose of testing for the MRS?
8 DR. MILLER: Yes, I brought this up within our
9 department, with our fish health group, I guess it
10 was in July of this year, once we had obtained the
11 virus sequence for the parvovirus, and we've done
12 a fair amount of screening of wild fish to know
13 that this is a virus that is highly prevalent in
14 sockeye salmon that we observe in the same tissues
15 that we observe this signature in, and we are
16 doing some large-scale surveys, both of sockeye
17 salmon and of hatchery and wild chinook and coho
18 salmon and so I felt that it was time that we also
19 look at a broader range and look at the
20 aquaculture and, specifically, Atlantic salmon, as
21 well. We do know that this signature and the
22 virus are found in chinook salmon, but I have not
23 had any samples of Atlantic salmon. There was
24 some discussion about this and whether or not this
25 was the time to test because we haven't
26 demonstrated in a laboratory that this virus can
27 cause disease, that it can cause mortality, and
28 that is work that is ongoing that Kyle and I are
29 working on now. And so there were questions as to
30 whether or not we should be testing now or wait
31 till we had all of that information, and I know
32 that there were some emails that came out because
33 of that meeting.
34 Since that meeting, I met again with Mark
35 Saunders and Andy Thompson, as well as, I believe,
36 Stewart Johnson was there, as well, and Andy
37 suggested that he simply approach the industry
38 about this, you know, and see if they would be
39 willing to collaborate with us to test their fish,
40 and they've agreed to do so.
41 Q So as it stands, though, and just to clarify, you
42 have asked for Atlantic salmon samples from fish
43 farms to test for the MRS signature, and you have
44 not received them and you have not tested Atlantic
45 salmon fish farms for the presence of the MRS?
46 Leaving aside the tests for parvovirus, you have
47 not looked at these fish for MRS?

1 DR. MILLER: No, we haven't.
2 Q Okay. Now, going back to your Science paper, when
3 you find a genomic profile like MRS, does that
4 tell you with certainty what caused that profile?
5 DR. MILLER: No.
6 Q Looking at which genes are turned on and which
7 genes are turned off, does that give you an
8 inference or lead to a hypothesis as to the cause?
9 DR. MILLER: It absolutely does. I mean, the whole
10 point of this program of using genomics is a way
11 of assessing whole organismal physiology, and
12 there are a plethora of controlled laboratory
13 studies that have shown a genomic response to a
14 variety of different environmental stressors,
15 toxicants, diseases, et cetera. And so we use
16 that information as a backdrop so that when we
17 obtain a genomic signature, we can then look to
18 see what are the similarities between the
19 signature that we are observing with other
20 controlled studies. And it is from that kind of
21 analysis, which we call a functional analysis,
22 that we proposed that this signature, the most
23 likely explanation for this signature is that it
24 is virally mediated, that it's a response to a
25 viral infection. And in the particular case of
26 this signature, the more data that we obtain, the
27 more validation we get for that hypothesis. In
28 the beginning, it was based on what we observed in
29 the paper, in the Science paper, based on the
30 genes that were being stimulated, the biological
31 processes that those genes were involved in, which
32 involved a number of immune system processes that
33 were specific to fighting viruses or intracellular
34 pathogens. 65 percent of the processes that were
35 affected were processes that were known to be
36 affected by viruses.
37 In addition to that, when we started seeing
38 this signature in other tissues, again, the fact
39 that this signature was present in other tissues,
40 but was not necessarily present in all tissues
41 within an organism at once really fits well with a
42 pathogen kind of model. It doesn't fit very well
43 with a general stressor or other kinds of things
44 that one could evoke to explain a signature of
45 this nature, and it does not fit well with a
46 toxicant kind of exposure where toxicants would
47 exert an effect primarily on the liver tissue

1 because that's a detoxification tissue, and then
2 it might, you know, have weaker effects on other
3 tissues. In this particular case, we could see
4 strong effects in a liver tissue and no effect on
5 a brain, we could see strong effects on a brain
6 tissue and a gill tissue and no effect on a liver.
7 This is much more a pattern that is associated
8 oftentimes with pathogenic agents.
9 Q Okay. And I believe we do have your hypothesis
10 about the virus in the Science paper, it's on page
11 216 of the document we have on screen, and I'll
12 read it to you. I'm sure you're very familiar
13 with it. The last sentence, there, says:
14
15 Our hypothesis is that the genomic signal
16 associated with elevated mortality is in
17 response to a virus affecting fish before
18 river entry and that persists to the spawning
19 areas.
20
21 And you've described, as I understand it, some of
22 the gene signalling that you observed and that led
23 you to that hypothesis, but I just want to
24 understand, when you say "hypothesis," does your
25 Science article conclude that a virus is causing
26 the fish to die en route, or at the spawning
27 grounds?
28 DR. MILLER: No, it does not. And I think that I
29 should clarify that in my view, the most important
30 finding in this Science paper is that the fish are
31 already conditionally challenged before they're
32 entering the river. A lot of the work that my
33 colleagues have done, Scott Hinch and Tony
34 Farrell, has also seen this using what I would
35 call directed physiological indicators for stress,
36 for osmo-regulation, for maturation, and for
37 energy, and they have seen, in other years that
38 involved radio tracking, that there was a
39 correlation oftentimes with stress and with osmo-
40 regulation in terms of successful migration. But
41 from those studies, they could never really
42 propose a mechanism for why some of the fish were
43 sometimes much more ready for freshwater, why
44 there was a portion of fish that were so ready for
45 freshwater that they probably would be
46 uncomfortable in the marine environment, and why
47 there were so many stress indicators in those

1 fish. We understood genomics to try to provide a
2 much deeper level of understanding of the
3 mechanisms that might create the kinds of patterns
4 that they were observing. This study absolutely
5 was a really good follow-up to what they found
6 and, in fact, we found that these same fish had
7 the same difficulties with osmo-regulation in that
8 they showed a pattern of osmo-regulatory
9 preparedness when they were 200 kilometres in the
10 river that looked like a freshwater fish. They
11 were probably very uncomfortable in the marine
12 environment.
13 All that is to say that what we have seen
14 here provides a deeper mechanistic understanding
15 to what I believe that they have observed in
16 previous years using other kinds of markers that
17 only allow them to know that fish were stressed
18 and had differences in osmo-regulatory
19 preparation, but didn't provide any kind of
20 mechanistic explanation.
21 At the time of this paper, that this was
22 caused by a virus was a hypothesis, we did not
23 have a specific virus.
24 Q So at the time of this paper, for example, if
25 someone were to cite this Science paper as proof
26 that a virus was killing sockeye salmon, would
27 that be correct?
28 DR. MILLER: That would not have been the way I would
29 have cited this paper. To me, this paper was
30 proof that river conditions alone are not probably
31 the only indicators or only exacerbating factors
32 in terms of salmon mortalities. I mean, we have
33 had mortalities of salmon in the river. Up to 99
34 percent of some stocks in some years have died
35 before they spawned and, really, there is very
36 little understanding for why that occurs. A lot
37 of the research is focussed on the river
38 environment, around the temperatures in the river,
39 around the pathogens that they pick up when they
40 enter the river. This is the first study that
41 says, "Look, this could be a pathogen that they
42 carry in with them into the river, not simply
43 something that's picked up in the river, that
44 might also be undermining their performance."
45 It's probably not the only thing undermining their
46 performance, but what this study showed was that
47 fish were already compromised before they enter

1 the river, and I believe that that is what we are
2 going to find, as well, with smolts.
3 Q Okay. So moving along with the viral hypothesis,
4 I understand -- Dr. Garver, this is where you fit
5 in -- now, have you done work on trying to
6 identify this virus that's related to the MRS?
7 And, in particular, I'm interested in your work
8 with Dr. Tang of the BCCDC, if you could tell us
9 about that, please?
10 DR. GARVER: Yes, when Kristi first approached me
11 regarding a hypothesis about a virus potentially
12 being associated with the MRS, I suggested several
13 different diagnostic methods that we could try to
14 get at the answer of if there is indeed a virus in
15 these tissues that she's characterizing as
16 unhealthy or having the MRS. And so to do that,
17 one approach was a traditional virological
18 approach, and this is kind of a broad method in
19 which you put the sample onto cell culture. And
20 so this is in vitro, you grow fish cells, you put
21 the sample on the tissue and you observe for virus
22 infectivity in those tissues. So we tried various
23 different cell lines. We weren't fortunate enough
24 to culture any virus, but, again, it's a broad
25 technique and a lot of viruses are unculturable.
26 Another method that we're trying, and my
27 research program is quite interested in developing
28 novel detection methods for viruses, and so one
29 area we're pursuing is a technology similar to the
30 microarray technology that Kristi is using for
31 gene expression, but we're looking at a microarray
32 that is able to survey for thousands of viruses at
33 one time. So basically, it's a slide that has
34 thousands of viral sequences on that slide, and
35 you basically apply your sample to that slide and
36 if there's a virus in your sample that is
37 complementary to one of those on the slide, you
38 will get a fluorescent and, hence, an indication
39 that you have a particular type of virus. And so
40 this is called -- the person that developed it was
41 Joe DeRisi, down in the University of San
42 Francisco. It's called the ViroChip. We're into
43 several generations of it now. As new sequences
44 come in, it's updated. And so what we did is when
45 Kristi approached me, we took the MRS tissues
46 versus tissues that were not exhibiting an MRS
47 sequence and we applied these to the slide. And

1 at the time we did the analysis, I should also
2 point out that we're also validating this chip to
3 work on fish viruses. It's mostly used in human
4 virus. So predominantly on the slide, the
5 sequences that are there are human viruses.
6 That's not to say that they don't have fish
7 viruses.
8 Q I just want to check that I understood you
9 correctly there. So you're working with Dr. Tang
10 from the BCCDC; is that correct?
11 DR. GARVER: That is correct, he has the slide.
12 Q And you've referred to this slide, is this also
13 called the ViroChip?
14 DR. GARVER: The ViroChip.
15 Q And how did Dr. Tang learn how to use the
16 ViroChip?
17 DR. GARVER: Dr. Tang did a post-doctoral fellow
18 research position with Joe DeRisi, the developer
19 of the chip.
20 Q So that means he's worked with the inventor of
21 this chip; is that right?
22 DR. GARVER: That’s correct.
23 Q Would you say he's fairly experienced in using it?
24 DR. GARVER: Yes.
25 Q And just so I understand the technology that you
26 just explained, this ViroChip is a tool to test
27 for the presence of viruses?
28 DR. GARVER: That’s correct.
29 Q And it's a microarray, as you said, and it
30 contains bits of genetic material representing all
31 known viruses; is that right?
32 DR. GARVER: That is correct.
33 Q And the idea is you take a sample, for example,
34 from a fish, process it, put it on the ViroChip
35 and if I understand you correctly, if your sample
36 contains a bit of viral genetic sequence matching
37 what's on the microarray, the ViroChip, you will
38 see a positive signal; is that right?
39 DR. GARVER: That is exactly right.
40 Q Okay. So has this ViroChip been used to discover
41 new viruses before?
42 DR. GARVER: It has. Actually, it first really made
43 its highlight and its use with the SARS virus.
44 Q Okay.
45 MS. CHAN: If I could have Canada's Tab number 7
46 brought up, please? This is Canada's Tab
47 number 7? Is this the correct one, for diseases?

1 I believe they have a separate list for today.
2 Thank you, Mr. Lunn.
3 Q Do you recognize this paper on the screen?
4 DR. GARVER: Yes, I do.
5 Q It's titled, "Using a Pan-Viral Microarray Assay
6 (Virochip) to Screen Clinical Samples for Viral
7 Pathogens." And I see there that Joseph DeRisi is
8 one of the authors, and you just told us that he
9 was an inventor of this ViroChip?
10 DR. GARVER: Yes, he was.
11 Q Does this paper set out the protocol to be
12 followed when using the ViroChip?
13 DR. GARVER: I believe so. Yes, it does.
14 Q Would it be the protocol that you would have
15 followed?
16 DR. GARVER: Yes, we would use something very similar
17 in Patrick's lab.
18 Q Okay. And when you then used this chip and this
19 protocol, what did you find when you compared the
20 MRS positive fish and MRS negative fish?
21 DR. GARVER: At the time when we did the analysis, we
22 didn't see any conclusive viral signal coming from
23 -- in other words, there was no significant
24 difference between the MRS sample and the non-MRS
25 sample so we were unable to differentiate
26 conclusively if there was a specific virus between
27 the difference between the two samples.
28 Q So there was no difference?
29 DR. GARVER: There was no difference.
30 Q Did it indicate the presence of any novel viruses?
31 DR. GARVER: No, we weren't able to find any viral
32 signals that cropped up in the MRS, however, I
33 should note, this technology, there are some
34 limitations to it, one being it is a hybridization
35 so you need a lot of sample and if you suspect
36 there's a virus in your sample, you need a lot of
37 virus to be able to bind to produce a signal. So
38 if you don't have ample quantities in your sample
39 of that virus, you will not detect it. Another
40 significant feature of this is it's based on all
41 the known viral sequences in a public database.
42 And the problem with that is if there's new
43 viruses that are significantly different than
44 those that are appearing on the chip, you won't
45 get hybridization. So there's two limitations,
46 you need a lot of virus to find binding, but you
47 also need something that's at least genetically

1 similar to what's on the viruses. So if it's
2 quite a bit different than what's on the viruses,
3 it won't bind and give you a fluorescent signal.
4 Q Okay. So a negative signal, does that necessarily
5 mean that the virus isn't there?
6 DR. GARVER: No.
7 Q Okay. If I could --
8 DR. MILLER: Can I just add something?
9 Q Oh, yes. Oh, your microphone, please.
10 DR. MILLER: In general, this chip has been used with
11 cultured viruses and one way to get a lot of viral
12 concentration is through culturing viruses on
13 cells. It's application for use using a tissue
14 sample where you're trying to get enough virus out
15 of a tissue sample, it hasn't been used anywhere
16 near as much. There's other issues associated
17 with using a tissue sample in that when you have a
18 tissue sample, you also have the background of the
19 genome of whatever animal you obtained that tissue
20 sample from. And so there were some questions
21 about how one might deal with that in terms of the
22 way that the data are treated and the data are
23 normalized, et cetera, and so really, we were
24 exploring not only, you know, could we pick up any
25 kind of signal from this from a tissue sample,
26 because that's what we had, but also, you know,
27 are there methods that could be used to better
28 tease out, you know, the background that the
29 salmon genome would have on the slide.
30 DR. GARVER: And I can add one other point. We have
31 been validating this chip since and we have
32 conducted it on tissues, as well as amplified
33 isolates, as Kristi's alluding to, and it does
34 work with both, particularly for fish that have
35 exhibited disease signs due to a viral signal.
36 And so particularly, the main diseases that I work
37 on, IHN, VHS, it's worked considerably well for
38 those.
39 MS. CHAN: Okay. If we could return to Tab 22, please.
40 I think that is now -- oh, and first, perhaps, if
41 I could mark this paper as the next exhibit?
42 THE REGISTRAR: Exhibit number 1514.
43
44 EXHIBIT 1514: Video article entitled, "Using
45 a Pan-Viral Microarray Assay (Virochip) to
46 Screen Clinical Samples for Viral Pathogens"
47

1 MS. CHAN: And returning to Tab 22 of the Commission's
2 list, please? I believe this is now Exhibit 1512.
3 If we could go to the second page, please, near
4 the bottom?
5 Q I'm just going to read to you the second bullet
6 from the bottom, there. It says, under the
7 heading, "Additional Evidence of Potential
8 Pathogen Involvement," and this is returning to
9 you -- Dr. Miller, your presentation at the PSC in
10 June of 2010:
11
12 A VIRAL PATHOGEN?: In collaboration with
13 B.C. Centre for Disease Control, we ran both
14 healthy and unhealthy RNA on a Viral Array
15 (used to identify viral strains in humans and
16 agricultural animals), and found the
17 unhealthy tissue gave 6x higher intensity
18 binding to the array than healthy tissue.
19 There was a 3-fold over-representation of
20 Retroviral family DNA.
21
22 So when I read that, it seems to me to differ from
23 the conclusion that Dr. Garver just described,
24 saying that there was no difference between the
25 MRS positive and the MRS negative fish. Can you
26 explain that?
27 DR. MILLER: Okay. Yes, sure. In the methods that Dr.
28 Tang uses on these arrays, again, they usually are
29 using cell culture. And one of the issues with
30 dealing with a tissue culture is that you have a
31 much higher background binding because you have a
32 lot of other DNA in the mixture. And I spent
33 considerable time with post-doc there and
34 discussed. They don't normally -- anytime anyone
35 runs a microarray, you always have to background
36 correct for what's the background fluorescent
37 signal on the array because you only really want
38 to demarcate what's the signal on each of the
39 spots on the array. And in every slide, you're
40 going to have a different level of background, and
41 so unless you correct for that, you really don't
42 know which of those spots are binding
43 significantly above background. And so I took the
44 slide results into my lab and treated it like we
45 would treat any of our other microarray slides and
46 background corrected it. And when I did that,
47 another typical measure used in microarrays is to

1 only count spots that have at least two standard
2 deviations greater binding from the background
3 intensity. Okay, so you're trying to
4 differentiate what's nothing in terms of binding
5 and what's actually truly binding to something.
6 And we found when we did that analysis that we had
7 three different tissues that we ran for what we
8 called at the time, unhealthy, which is the same
9 thing as MRS and samples that we classified as
10 being healthy or non-MRS samples. And we found
11 that over all three tissues, the level of binding
12 to the specific probes on the array was six times
13 greater for the MRS positive or unhealthy positive
14 than the negatives.
15 Now, this is not a kind of measure that Dr.
16 Tang generally uses and but this was our own
17 observation. The other observation was if you
18 look -- there's a very different representation of
19 the different families of viruses on these arrays,
20 depending on how common those viruses are. There
21 is, you know, a plethora of herpes viruses and
22 retroviruses on those arrays. There's very few of
23 some of the smaller viral families. And so one of
24 the caveats of doing what I did in terms of
25 looking at higher-intensity binding is if you had
26 two samples and one of them was a herpes virus and
27 another one was a very uncommon or, you know, a
28 family that's not well represented on the array,
29 you know, you might incorrectly assume that the
30 one with the herpes virus is the one with the
31 virus and the other one isn't, which is a caveat
32 of using just this higher-intensity binding. But
33 what we found when we looked within family, so
34 when you took into account how many different
35 spots were present represented in each family, the
36 only family that had a higher representation in
37 the unhealthy or MRS tissue, compared to the other
38 tissue, was the retro-viral family DNA.
39 Now, I have to say one caveat to this is that
40 retroviruses can insert their DNA into the host
41 genome. Salmon carry all kinds of endogenous
42 retroviruses. Those are called endogenous, which
43 means that at some point that might have been, you
44 know, hundreds of years ago, even, retroviruses
45 have inserted their sequence into the DNA of the
46 host and it remains there. And so you do get a
47 background binding of endogenous retroviruses on

1 this array and we do find with the MRS signature
2 that we get a spike in the production of the RNA
3 that comes from those endogenous retroviruses,
4 which is one potential signal that there is a
5 retroviral infection because, in general,
6 endogenous retroviruses can be stimulated by
7 exogenous retroviruses so those are self-
8 replicating retroviruses. So that, I believe, is
9 what led to this over-representation of the
10 retroviral family.
11 Q At this point in time, when you wrote this
12 presentation, was it your hypothesis that a
13 retrovirus was the cause of the MRS?
14 DR. MILLER: That was a sub. I mean, our key
15 hypothesis was that it was viral and after that,
16 that it was possible that it was retroviral, and
17 there were a lot of elements within the genes that
18 were being stimulated that were known to be
19 stimulated and co-opted by retroviruses and so we
20 were quite interested in the potential for
21 retroviruses, recognizing that they are one of the
22 hardest families to try to work with.
23 I should also say that -- and I know you
24 don't want to get too far into the virus that we
25 did eventually identify in this tissue --
26 Q We will get there.
27 DR. MILLER: -- but the one comment about that when it
28 comes to this array is it only has about 30
29 percent homology and in order to get binding of a
30 virus, a good binding to this array, you need at
31 least 50 percent homology at a nucleotide level.
32 So the virus that we have identified is highly
33 divergent and would not have bound very
34 effectively to this array.
35 Q So that's just to say the negative result is not
36 definitive in your words; is that accurate, then?
37 DR. MILLER: Well, neither Kyle or I assumed that this
38 test would -- if you didn't get a positive result,
39 it didn't say there wasn't a virus, but we hoped
40 that it would be helpful.
41 Q Okay. So with the retrovirus as a sub-hypothesis
42 of the viral hypothesis, as you were saying, are
43 there some retroviruses that are known to cause
44 cancer?
45 DR. MILLER: Well, many retroviruses are oncogenic and
46 associated with cancer. I mean, the well known
47 ones are leukemia, but there's a swim bladder

1 virus that Atlantic salmon carry that is also
2 oncogenic so yes, they tend to be associated with
3 cancers.
4 MS. CHAN: If we could go to Tab 20, please, of the
5 Commission's documents? This is Exhibit 613G.
6 Q Dr. Miller, this is already an exhibit. Do you
7 recognize this as a presentation that you gave?
8 DR. MILLER: Yes, this was a presentation at the first
9 DFO meeting that we had, an intra-departmental
10 meeting where we were asked to look at each of our
11 research programs and that we wanted to start a
12 discussion in DFO about what various hypotheses
13 people had that might pertain to the salmon
14 declines, and this was a presentation that I gave
15 at that time.
16 Q When you say intra-departmental, who was in
17 attendance and --
18 DR. MILLER: It was only DFO staff, DFO scientists,
19 largely, but there were some managers in
20 attendance, as well.
21 Q Did you create this presentation based on that,
22 with the expectation that it would be broadly
23 distributed?
24 DR. MILLER: Actually, at the time, I was presenting it
25 as a presentation to stimulate discussion within
26 DFO about some of this work. I should say that at
27 this time, we had begun to suspect that our
28 signature could relate to a retrovirus. We had
29 also been looking closely about what we knew about
30 retroviruses in salmon and had found the
31 literature that Mike Kent and others had put
32 forward on the plasmacytoid leukemia or the salmon
33 leukemia virus, and so we had a considerable
34 amount of interest in that particular disease.
35 And we were hoping that through giving this talk
36 and putting forth to the Department the various
37 pieces of evidence that we had, that there would
38 be some expertise in the Department to move
39 forward with how do we determine whether or not
40 that particular disease is important.
41 Q Okay. Reading the title here, it says:
42
43 Epidemic of a novel, cancer-causing viral
44 disease may be associated with wild salmon
45 declines in B.C.
46
47 And I just want to move to page 7 of the

1 presentation, please, and here we have some
2 pictures. It says:
3
4 Large dark attached tumour mass
5
6 And I believe if we go to the next page, page 8,
7 just reading the top:
8
9 Optic lob is has large tumour mass and is
10 hemorrhagic (tumours are attached, blood is a
11 different consistency)
12
13 And I wanted to follow up with you, have you done
14 any additional work, or obtained any additional
15 information on these tumours?
16 DR. MILLER: I would like to provide the backdrop in
17 that one of the observations associated with
18 plasmacytoid leukemia was that they observed optic
19 tumours and so when we were talking to various
20 colleagues and trying to figure out what other
21 kinds of information could we glean from our fish
22 to try to match, to determine whether or not this
23 particular disease might be causative of the
24 signatures that we have, one obvious place to look
25 was to look for these optic tumours. And the
26 unfortunate thing when we started delving into
27 this was that nobody had tissue samples associated
28 with this particular disease. There were no
29 tissue samples left within DFO and nobody was
30 collecting them, and nobody was studying them in
31 British Columbia. And so we had gone and looked,
32 we had archives of hundreds or thousands,
33 actually, of brains in both smolts and adults, and
34 we went and looked at the optic lobes of those
35 brains to see if we saw any indications of
36 potential tumours. And lo and behold, we actually
37 did see that quite a large proportion of those
38 brains, on the outside of the optic lobe carried
39 very heavy vascularization, so blood vessels, and
40 in some brains, it would be very white-looking and
41 you wouldn't see this heavy vascularization, and
42 in other brains, you would see this heavy
43 vascularization. When you opened up the optic
44 lobe, in a good portion of those brains, you would
45 see what looked like these pink mass growths, and
46 you could see them connected to the blood vessels
47 inside. Blood, loose blood is quite a different

1 consistency, it's quite dark, it's not attached,
2 you can just pick it up. Some of this was just,
3 you know, a few cell layers deep of heavily
4 vascularized, very pink tissue, compared to a very
5 white background. And so we talked at the time,
6 we brought the Fish Health staff up to see if
7 anyone had observed the tumours associated with
8 plasmacytoid leukemia and no one knew what they
9 looked like. And I asked if anyone had seen
10 anything like this. So we consulted the staff and
11 they suggested we do histology to determine
12 whether or not these are tumours.
13 Q Okay. And with that background, are these
14 tumours?
15 DR. MILLER: The time I gave this talk was right in the
16 middle, when we were doing all of this, and about
17 a month-and-a-half after I gave this talk, we had
18 the results from histology and the histology
19 results, which were read by Gary Marty, suggested
20 that these were haemorrhages.
21 Q Not tumours?
22 DR. MILLER: Not tumours.
23 Q So we're looking at this one exhibit that refers
24 to tumours and with this same clarification that
25 you've just given, that these are not tumours,
26 would that apply equally to other documents
27 regarding your research that referred to tumours?
28 DR. MILLER: Yes. This is the main document, and we
29 probably should have used the term "lesion," not
30 "tumours" here because we hadn't established that
31 they were tumours at this time. I think the
32 reason that that jump was made was because they
33 were tumours in association with plasmacytoid
34 leukemia. The other thing that wasn't revealed to
35 me until a much later time was that Mike Kent
36 never actually looked at brains in his studies of
37 plasmacytoid leukemia. The tumours that they
38 found were observed in the back of the eye and not
39 in the optic lobe. That was not clear from the
40 literature, they simply called them "optic
41 tumours." And if you listened to Dr. Kent's
42 testimony just a couple of days ago, he backed up
43 a little bit about that even being tumours. He
44 suggested that the lesions that he saw on the back
45 of those eyes might have actually been
46 inflammation and not tumours. We were going by
47 the information that we had associated with this

1 disease. Now it seems that there's a lot of
2 backtracking on that information by the experts on
3 that disease.
4 Q Okay. If we turn to page 11 of this presentation,
5 just reading the title at the top, it says:
6
7 Strong Linkages of Genomic and Brain Tumour
8 Data With Plasmacytoid Leukemia caused by the
9 Salmon Leukemia Virus.
10
11 Now, you've just clarified that these weren't
12 brain tumours. Did you find any linkages between
13 these what you thought were tumours and the
14 mortality-related signature?
15 DR. MILLER: Okay. The answer is no, but you have to
16 understand that at the time that we were
17 dissecting these brains for looking in the optic
18 lobes, in order to do microarrays, we have to take
19 RNA from an entire brain and so all of our studies
20 that delineate this signature would have used up
21 all of the brains. And so when we went to look
22 for evidence of plasmacytoid leukemia in these
23 brains, we had to sample brand new brains. So we
24 followed this up with a study that where we had
25 scored individual brains for whether or not they
26 contained these lesions, which turned out to be,
27 according to Gary Marty, according to a sample
28 size of about 12 fish, that turned out to be
29 haemorrhages and from that, we determined that our
30 signature was not correlated with the presence of
31 these lesions.
32 Q Are you still looking to plasmacytoid leukemia or
33 salmon leukemia virus as a possible cause of the
34 MRS?
35 DR. MILLER: I have not discounted it, but it is not
36 something that's going to be easy to get to
37 because there are not people who are studying it
38 and there are no samples available of fish that
39 are positive for plasmacytoid leukemia. And now,
40 if you look at what the experts had to say in the
41 last couple of days, they're even kind of
42 backtracking on whether or not it is a single
43 disease or whether the histological signature
44 might be associated with a variety of different
45 pathogens. So it's still of interest to me,
46 mostly because of the history in terms of when it
47 was first observed, that sockeye salmon was shown

1 to be highly susceptible to it. I have not
2 discounted it, but I am at a bit of a loss as to
3 where to move forward with it.
4 MS. CHAN: If we could have Tab 26 of the Commission's
5 documents, please?
6 Q There are two documents that are at Tab 26, one is
7 an email and one is what looks like a memorandum
8 to the Minister, or at least a draft with some
9 comment bubbles on the side, and Dr. Garver, we
10 have this document from you. Do you recognize
11 this as a memorandum with your comments on the
12 side?
13 MS. CHAN: Perhaps if we bring up the email that
14 attaches this document.
15 Q Do you recognize this as an email from yourself to
16 Dr. Miller?
17 DR. GARVER: I do, yes.
18 MS. CHAN: And if we could have this marked as the next
19 exhibit, please?
20 THE REGISTRAR: Exhibit 1515.
21
22 EXHIBIT 1515: Email dated 2009-Oct-08 from
23 Kyle Garver to Kristi Miller-Saunders
24 entitled, Re: Ministers memo - DRAFT
25
26 MS. CHAN: And if we could go to the document that's
27 attaching it, or that's attached to it. I'll just
28 read some of these thought bubbles. If we could
29 have this document marked as the next exhibit
30 after, so it would be 1516, please?
31 THE REGISTRAR: That's correct, 1516.
32
33 EXHIBIT 1516: Memorandum for the Minister,
34 "Epidemic of a Novel, Cancer-causing Viral
35 Disease may be Associated with Wild Salmon
36 Declines in B.C."
37
38 MS. CHAN:
39 Q So the title, "Epidemic of a Novel, Cancer-causing
40 Viral Disease may be Associated with Wild Salmon
41 Declines in B.C.," that seems to be the same title
42 as the previous presentation we just saw. And
43 just looking at some of the thought bubbles, Dr.
44 Garver, you're saying an alternative title
45 suggestion, and the second one down:
46
47 Decline in tumour prevalence does not

1 necessarily mean fish with tumours died, it
2 could simply tumours regressed.
3
4 And the third thought bubble:
5
6 Is there strong evidence to directly link
7 tumour decline and mortality?
8
9 What was the context of this and what was the
10 message that you were trying to convey in your
11 email in this attached comments to Dr. Miller?
12 DR. GARVER: My main concern with this document at the
13 time, and Kristi alluded to this, the genomic
14 profiling is not a definitive diagnostic. So in
15 other words, to be able to link it to a specific
16 virus, in other words, differentiate between
17 Virus A versus B, you really need to know what
18 those signatures of those viruses are to
19 differentiate. And in fish health, as far as
20 genomic profiles, as far as obtaining those
21 signatures of different viruses, say we have
22 Virus A and Virus B, we need to determine that
23 signature. And in fish health, that just hasn't
24 been done. So there is no biomarker or signatures
25 for specific viruses. There is a few, but to say
26 that it's a retroviral agent, I just was not
27 comfortable in that the data suggested that so I
28 tried to rephrase it to "viral disease."
29 Q Now, I'm looking at the time, and just to move on
30 to the current hypothesis, which, Dr. Miller,
31 you've mentioned a parvovirus, so when did you
32 find this parvovirus and how did you find it?
33 DR. MILLER: With Dr. Garver's help, we attempted to
34 isolate viral particles from tissues that contain
35 the MRS. We did this through using sucrose
36 gradients, which is a technique that's often used
37 to isolate viruses and then we extracted DNA and
38 RNA from those and we sent them off to a genome
39 centre in Quebec to be sequenced. And we used 454
40 sequencing, which is a very rapid sequencing
41 technology that allows you to get hundreds of
42 thousands of reads very cheaply and quite quickly.
43 We obtained the results from that in early
44 2011 and we identified the parvovirus using
45 bioinformatic approaches in late February of 2011.
46 Parvoviruses are a small DNA virus and so we did
47 about 260,000 reads from DNA that was isolated

1 from MRS-positive livers of smolts and adults. We
2 found the parvovirus sequence in both the positive
3 smolts and adults and we found it 76 times. And
4 we obtained a sequence that was about half the
5 size of the genome so we have about 2,200 bases of
6 the sequence. And it's probability value of being
7 a parvovirus sequence is E to the minus 63. It's
8 a very, very powerful positive for a parvovirus.
9 We have since aligned it with the conserved
10 regions of a number of parvoviruses and shown that
11 it contains all of the -- all of the conserved
12 regions are conserved in this virus, as well.
13 Q You mentioned you have part of the DNA sequence.
14 If it's a DNA sequence, is it a retrovirus, then?
15 DR. MILLER: No, it's a parvovirus. It's in the
16 parvovirus.
17 Q Not in the retrovirus?
18 DR. MILLER: Not in a retrovirus.
19 Q You mentioned finding it in MRS positive samples.
20 Have you found it in MRS negative samples?
21 DR. MILLER: Well, so we didn't run the sequencing on
22 MRS negative samples, but we developed molecular
23 markers for this virus and have screened
24 individuals that we have run on microarrays in the
25 past, and it is associated with the presence of
26 the MRS in liver tissue. That's the one tissue we
27 validated so far. That's the tissue we observed
28 this in originally.
29 Q Have you ever found the parvovirus in tissues that
30 were MRS negative?
31 DR. MILLER: We did not find it in any of the livers
32 that were MRS negative.
33 Q Any of the other tissues that were MRS negative?
34 DR. MILLER: We are in the throes of doing that. One
35 of the difficulties that we had was that if you
36 look at the Science paper, we used non-
37 destructively sampled gill tissues and all of the
38 genomic work is based on RNA, which is different
39 from DNA, and in order to get enough RNA to run on
40 microarrays, you have to use an entire sample.
41 And so we did not have tissue remaining to extract
42 DNA to look for the virus in those particular
43 samples. So that is something that we're doing
44 over samples from other studies that we have
45 identified the MRS in.
46 Q And Dr. Garver, I understand that you're involved
47 in this work, as well. Now, for a parvovirus,

1 parvovirus, is that seen in other animals?
2 DR. GARVER: It has been observed.
3 Q Microphone, please.
4 DR. GARVER: Yes, the parvovirus has been observed in
5 other animals.
6 Q When it's observed in other animals, is it of a
7 size that if you have the right kind of
8 microscope, say, a scanning electronic microscope,
9 is it visible?
10 DR. GARVER: It is visible, yes.
11 Q Have you looked for parvovirus particles in these
12 MRS positive tissues?
13 DR. GARVER: We have not done that yet, no.
14 Q Do you intend to?
15 DR. GARVER: That is one of the diagnostics that we
16 plan to do.
17 Q Are you working on testing infectivity of the
18 parvovirus?
19 DR. GARVER: Yes, so when you have a disease agent or a
20 etiological agent that might be causing a disease,
21 one of the first things you need to do is identify
22 if it is transmissible, if it's infectious. And
23 so when Kristi came up with this sequence,
24 identified this sequence, we then proposed to take
25 those infected tissues and see if they are
26 infectious to naive hosts. And so what that means
27 is you take the infected tissue and inject it or
28 subject it to a naive host, in this case, sockeye
29 salmon that are thought to be free of the
30 parvovirus, and then we look for transmission of
31 that agent to see if it is indeed infectious. And
32 more in particular, then you follow that infection
33 study and look for disease signs and you do that
34 using pathology and histology.
35 Q And have you found that it's infectious?
36 DR. GARVER: That's a good question. We just started
37 that challenge yesterday, actually.
38 Q Okay. So still in progress. Now, if there's a
39 parvovirus in these fish, does it necessarily mean
40 that there's going to be a disease?
41 DR. GARVER: No, not necessarily. As in probably the
42 past two days, I’m sure you've heard, not all
43 pathogens equate to disease. It's a complex,
44 multi-factoral interaction among the host/pathogen
45 environment to actually get what we call the sweet
46 spot of disease.
47 Q Is it possible that the parvovirus is not

1 associated with any disease in these fish?
2 DR. GARVER: It's possible, yes.
3 Q That's something under investigation?
4 DR. GARVER: Yeah, that's exactly what we're looking
5 for, to see if there is disease that is associated
6 with the parvovirus.
7 Q And Dr. Miller, you alluded to this earlier, are
8 you looking for the parvovirus in Atlantic salmon
9 fish farms?
10 DR. MILLER: Yes, we will be as soon as we get the
11 samples, yes.
12 Q And are those on their way to you?
13 DR. MILLER: This all came about about a week before I
14 was due to testify, and that was when we had the
15 agreement that the four major salmon farming
16 companies would work with us on a sampling
17 program, and I believe after the aquaculture
18 hearings, I will be getting together with the vets
19 and Kyle and we will be designing a sample program
20 for the industry because I want to make sure that
21 we cover the life history stages where we've seen
22 this virus in wild fish.
23 Q All right. Now, I see that I'm nearing the end of
24 my time. As my last issue to put to you, it's
25 something that's been raised as an issue recently,
26 and that is whether or not anyone at DFO, any of
27 your superiors, have ever told you not to speak to
28 the public, not to speak to other scientists, or
29 not to share your research? Has that ever
30 happened?
31 DR. MILLER: Well, yes, I'm not to speak to the public
32 because of the ongoing inquiry. I am free to
33 speak with colleagues and other scientists, and I
34 have been able to attend some scientific meetings.
35 Q Have you ever been told not to attend a scientific
36 meeting?
37 DR. MILLER: Yes.
38 Q And when was that?
39 DR. MILLER: Well, it was really a think tank, an SFU
40 think tank, but it wasn't me exclusively. DFO
41 decided that nobody, no scientist from DFO was to
42 attend that meeting.
43 Q Have you ever been told not to publish your
44 research?
45 DR. MILLER: No, absolutely not. You know, this is one
46 of my worries with this whole process and the way
47 that this has played out in the media, you know,

1 the integrity of science in DFO is absolutely
2 withheld. As scientists, you know, we do our
3 research, we come up with our conclusions, we
4 write our papers and there's nothing to stop us
5 from publishing our research anywhere that we
6 would like to publish our research. We do provide
7 a reprint of what we are going to be submitting
8 for publication, but there has never, to my
9 knowledge, been anyone who's been prevented from
10 publishing their research.
11 Q And you said that at DFO, science integrity has
12 been withheld, and what did you mean by that?
13 DR. MILLER: I mean the integrity of the science is
14 strong, that there's nobody telling anybody what
15 they can and can't publish or what they can or
16 can't say in a publication.
17 Q Have you ever been told not to research a
18 particular issue?
19 DR. MILLER: Probably, the answer would be yes, and not
20 pertaining to this, but you know, we, as employees
21 of the federal government, need to make sure that
22 our programs fall within the mandate of DFO and
23 that we are doing research that fulfills that
24 mandate. I can't think of a specific example, but
25 there certainly could be examples of areas of
26 research that DFO did not deem to be within their
27 mandate. So that's certainly a possibility. I
28 can't think of a specific example.
29 MS. CHAN: Mr. Commissioner, those are my questions and
30 perhaps this would be a good time for the break.
31 THE COMMISSIONER: Yes, thank you very much, Ms. Chan.
32 It's 11:20.
33 THE REGISTRAR: The hearing will now recess for 15
34 minutes.
35
36 (PROCEEDINGS ADJOURNED FOR MORNING RECESS)
37 (PROCEEDINGS RECONVENED)
38
39 THE REGISTRAR: The hearing is now resumed.
40 MR. MARTLAND: Mr. Taylor is looking over so maybe I
41 will rise just to say Canada is the next
42 participant examining this panel. It's 65
43 minutes.
44 MR. TAYLOR: Mitchell Taylor for the participant,
45 Government of Canada. Mr. Commissioner, with me
46 is Jonah Spiegelman. And as I mentioned the other
47 day, a law student, Jeff Miller, is with us as

1 well.
2
3 CROSS-EXAMINATION BY MR. TAYLOR:
4
5 Q I'm going to start by asking both of you some
6 questions that are picking up on some things that
7 Ms. Chan asked you and then I'll proceed to ask
8 some questions of Dr. Miller and then Dr. Garver.
9 Now, Dr. Miller, you said at one point in
10 answering a question from Ms. Chan that the
11 signature was found in at least one tissue of a
12 lot of fish but it's important to see it in more
13 than one tissue. Do you recall that? And can you
14 expand on your point about more than one -- seeing
15 it in more than one tissue?
16 DR. MILLER: Sure. Yes, I did make that statement and
17 it is my view, if this is validated to be a viral
18 infection, which is something we now have a
19 candidate virus and it's something that we are
20 working on, it's probably the intensity of
21 infection that really matters here, not that a
22 salmon is simply a carrier in a single tissue.
23 And Kyle may be able to comment further on this.
24 When there is an active infection, that infection
25 can spread through a large number of tissues. But
26 you can have, in a less active infection, a
27 positive for a virus that, in a single tissue or
28 maybe even in one or two tissues, that's not
29 highly active at the time.
30 And so in my view, if we do validate that
31 this is caused by a virus and is caused by the
32 parvovirus, in particular. Probably the level of
33 infection and the level of infection in multiple
34 different tissues and the copy number of the virus
35 in multiple different tissues would probably be
36 the best indicator of potential negative impacts
37 on those fish. That is certainly something that
38 came from our comparison of 2007 and 2008, out-
39 migrating smolts. The really big difference
40 between them was at the time that those smolts
41 were leaving the river in the brain and the liver,
42 virtually all of the fish in 2007, very small
43 sample size, but they all had the signature in
44 both tissues. And in 2008, very few of the fish
45 carried it in both of those tissues.
46 Q All right. Now, you were also asked about getting
47 fish from fish farms to do testing for your work

1 and you explained to Ms. Chan that that has
2 recently been set about to happen. As I
3 understand it, there's a process now where you and
4 veterinarians for the fish farms are developing a
5 protocol for getting the fish and then screening
6 and testing the fish; is that right?
7 DR. MILLER: Yes, I haven't actually spoken
8 specifically to any of the veterinarians yet. I
9 have had email contact with Mary Ellen Walling and
10 she has spoken to various vets but that is the
11 procedure that we will work with the vets and
12 design a sampling program.
13 Q And as you explained earlier, but just to remind
14 us all, Mary Ellen Walling is the executive
15 director or similar title for the Salmon Farmers
16 Association, is she?
17 DR. MILLER: Yes, that's my understanding.
18 Q And why is it important as a scientist to get a
19 protocol for your screening and testing in place,
20 as opposed to just doing it?
21 DR. MILLER: Well, it's important if was want to know
22 -- you know, ideally, one would do this over
23 multiple years and determine whether or not
24 Atlantic salmon and other species can carry this
25 virus over multiple years. I think in the
26 beginning we're really just going to look at a
27 single year of samples but we need to get a broad
28 range of samples from similar life history stages,
29 as what we've seen in wild fish. We see in wild
30 fish a lot of fish coming out of the rivers with
31 this virus and it's the virus that we're looking
32 for in the industry in the beginning, not the
33 signature. And we see, you know, that there are
34 shifts in prevalence during their time of ocean
35 residence. So I would like to be able to get
36 samples of Atlantic salmon coming out of the
37 rivers before they're put on the open net pen
38 farms and also at various different stages of
39 development of those Atlantic salmon on the net
40 pens. And specifically getting samples of salmon
41 during times when wild salmon might be migrating
42 by salmon farms.
43 Q Okay. So as I hear you, and trying to sum up, so
44 tell me if I've got it right or wrong, I think
45 you're saying that as a scientist you want to be
46 clear what it is you're getting and you want to
47 ensure that what's done is going to be

1 scientifically sound and consistent year-to-year?
2 DR. MILLER: Correct. I mean simply taking 20 fish
3 from a single salmon farm would not be adequate to
4 say whether or not that virus could be carried by
5 Atlantic salmon.
6 Q You can't just ad hoc it, so to speak?
7 DR. MILLER: I don't believe you can. And I think that
8 right now, this is a research question. I have to
9 be clear that we are interested in whether or not
10 this viral sequence is present in Atlantic salmon.
11 That doesn't necessarily equate to saying that
12 this viral -- this virus causes disease in
13 Atlantic salmon. That would be step two after we
14 determined if it was actually present.
15 Q All right. Is it your opinion as a scientist that
16 it is not scientifically sound to ad hoc it or do
17 one-offs or otherwise just go at it without a
18 clear protocol and plan in place?
19 DR. MILLER: I'm a very broad thinker and so when I
20 design a program, it usually ends up being very
21 broad and, yes, I do think that we have to go at
22 it with a protocol to make sure that we can
23 definitely say at least in the one year that we'll
24 start this work that there is or is not presence
25 of this parvovirus sequence in Atlantic salmon.
26 Q All right. Dr. Garver --
27 DR. GARVER: Mitch, I'd just like to add something on
28 top of this topic, as I also run up the diagnostic
29 portion of Virology Lab for the Aquatic Animal
30 Health program. And there is a clear protocol to
31 establish freedom from disease at sites. And I
32 believe Dr. Stephen has alluded to that in the
33 past two days. There's a strict regimen of how to
34 follow number of fish. As Kristi alluded to, you
35 want to look at your life stage, where the disease
36 is most prevalent, you need to know the prevalence
37 of the disease, you need to know what tissues that
38 disease is most prevalent in, you also need to
39 approach it with a validated diagnostic test. So
40 you have to be sure that the disease you're
41 looking for is going to be detected with your
42 method of detection that you're using.
43 Q All right. Thank you. And speaking even more
44 broadly than that, and as a scientist, do you
45 agree with what Dr. Miller was just saying about
46 having protocols and scientifically sound
47 methodology in place, as opposed to one-offs and

1 ad hoc and just getting whatever you get without
2 consistency and a clear plan?
3 DR. GARVER: Yes, most definitely.
4 MR. TAYLOR: Now, if I could ask Mr. Lunn to bring up
5 Exhibit 613G or Tab 20 of the Commission,
6 whichever is easiest? Yes, thank you.
7 Q Dr. Miller, you earlier identified that as a paper
8 that you presented to an internal DFO Science
9 meeting. And I'm not sure if you said when but do
10 you recall when that meeting was and this
11 presentation was made?
12 DR. MILLER: September 2009. The date on this document
13 says 2008 and that's a bad habit of mine that I
14 take previous slides from previous talks and I
15 overwrite them and I did not change the date on
16 this slide, which should have been 2009.
17 Q All right. And do I take it also that the 27, the
18 actual day, that's not necessarily correct?
19 DR. MILLER: The date on this, I simply missed changing
20 that date when I wrote this talk.
21 Q Now, you see the title at the top there, and this
22 is 2009 you wrote this, but knowing now what you
23 have in mind, would you use a different title on
24 that paper with the knowledge you have now?
25 DR. MILLER: Sure. You know, in science, it's
26 important to understand the scientific process.
27 As scientists, what we do is we gather information
28 either from published studies from other people or
29 from our own data and we develop hypotheses about
30 those and then we develop methods in which to test
31 those hypotheses to either support or refute the
32 hypotheses that we generate. At the time that
33 this talk was given, we were asked to put forward
34 hypotheses based on the data that we had at the
35 time.
36 At the time I gave this talk, the data that
37 was first and foremost on my mind because we had
38 just been doing all these brain dissections in
39 August and then trying to elicit interest in
40 people who had been working on plasmacytoid
41 leukemia to work with us on this, this was the
42 topic that was utmost in my mind. We were seeing
43 these what we thought were growths in the optic
44 lobe that were decreasing in prevalence in smolts
45 during their time in the ocean. So the highest
46 prevalence that we saw in smolts was coming out of
47 the river.

1 We saw a decrease in prevalence in the first
2 few months in the ocean. We also saw a decrease
3 in prevalence in adults of these brain lesions or
4 what were later determined to be aneurysms in
5 adult salmon returning to the river to spawn.
6 This was utmost in my mind, as was the MRS
7 signature, and this was the hypothesis that I put
8 together to elicit discussion about these findings
9 and this particular disease at our
10 intradepartmental meeting. But yes, knowing what
11 I know now, of course, I might call use a
12 different title.
13 MR. TAYLOR: Okay. Thank you. Now, if we might have,
14 if possible together, Exhibits 1515 and 1516 on
15 the screen.
16 Q And this is a question for you, Dr. Garver. While
17 it's coming up, this is the draft briefing note
18 from back in that same period of time, which has
19 in front of it the email you now see from you and
20 then the briefing note. And you're familiar with
21 this. It was up a few moments ago and you're
22 generally familiar with it, as I understand it,
23 Dr. Garver. This is the 2009 period of time that
24 you're writing the email and writing on the
25 briefing note. In what you were doing here and
26 the balloons that you can only see a part of to
27 the right. There we go. Is this you as a
28 virologist injecting a pound of caution and
29 suggesting some words that would avoid overstating
30 what the available information would support?
31 DR. GARVER: Yes, both as a virologist and a scientist,
32 I weigh the amount of evidence that's there and
33 make a conclusion based on that.
34 Q Okay. Thank you. Next, and this is still picking
35 up on a couple of points that Ms. Chan was asking
36 you about. There was reference in a question and
37 answer earlier to a think tank from sometime ago
38 and DFO scientists not going. And you recall that
39 evidence, I'm sure. Do you recall when that was
40 and when the rationale for DFO scientists not
41 going to that think tank was, Dr. Miller?
42 DR. MILLER: I believe that that was late in 2009 but I
43 don't know the exact date. At the time, DFO was
44 trying to get their mind around what the
45 Commission would want the scientists within the
46 Department to do in terms of how much we should
47 speak publicly about our work versus leave those

1 discussions to be something that we'll present in
2 the Inquiry. And I believe that they were
3 thinking that there might be some sort of ruling
4 from the Commission about that but that is
5 something that you'd have to ask the upper
6 managers. And I think that to be precautionary,
7 they decided that they would limit the exposure of
8 scientists to any meetings that were likely to
9 attract public attention and media. And that SFU
10 think tank was a meeting that they felt could have
11 some public interest and some media in attendance.
12 So they made the decision that no scientists in
13 DFO was to attend that meeting.
14 Q All right. Thank you. In terms of speaking with
15 the public now and of recent times, and this is a
16 question of both of you, Dr. Miller said earlier
17 that that's not to happen. Do you have an
18 understanding of why that's so, why the DFO
19 scientists right now are not to speak with the
20 public or give public interviews?
21 DR. MILLER: Well, I mean what we have been told is
22 that we're not to speak about our findings until
23 we testify here in the Cohen Inquiry. I don't
24 know at what point that ban in speaking to the
25 public will be lifted. I don't believe it is
26 lifted yet.
27 Q Do you have an understanding of the rationale for
28 that?
29 DR. MILLER: It's only the rationale I've been told.
30 As scientists, we're not very privy to the
31 conversation that goes on in Ottawa about these
32 sorts of things. We're sort of only told the
33 result.
34 Q Yeah. Perhaps a better question on my part,
35 what's your understanding of the rationale then?
36 DR. MILLER: Again, the understanding is that the
37 evidence supporting or refuting various hypotheses
38 should be heard first in the Cohen Inquiry before
39 it becomes something of public debate.
40 Q All right. Thank you. Dr. Garver, do you have
41 anything to add to that?
42 DR. GARVER: Yes, I basically was under the
43 understanding that we were respecting the Cohen
44 Commission process and presenting evidence here
45 first.
46 Q All right. Thank you. Just a couple of more
47 questions, Dr. Miller. Dr. Garver, you may have

1 something to add on this as well. When did you
2 identify the parvovirus and how did you find it?
3 DR. MILLER: We identified it from the sequences that
4 we obtained in late February. And what was the
5 second part of your question?
6 Q How was it found? I think you've spoken to some
7 of that before.
8 DR. MILLER: In late February of 2011, it was found by
9 basically we had about 260,000 reads for each of
10 DNA and RNA. You put those together in what's
11 called "contigs". Each of the individual reads
12 can be quite small. They can be anywhere from 200
13 to 500 bases so not a lot of sequence information.
14 Those are developed in looking for sequences that
15 overlap, that basically multiple sequences that
16 contain portions of the same sequence. And
17 they're built into something called "contigs",
18 which are basically a contiguous sequence of
19 representing basically a larger portion of a
20 general sequence.
21 Those were what we call "blasted", or sent to
22 various sequencing databases. There's viral
23 databases. There are sequencing databases for all
24 protein sequences that have been sequenced in all
25 organisms, et cetera. So we basically did
26 alignments using these public databases and
27 identified in every single one of those databases
28 that the parvovirus was the only significant hit
29 to that particular sequence.
30 Q Okay. It's sometimes called a novel virus and I
31 think novel virus has been used with the
32 retrovirus that was earlier talked about as well.
33 What is meant by "novel virus"?
34 DR. MILLER: Novel does not necessarily mean new.
35 Novel means that it is previously un-
36 described/unknown.
37 Q All right. Sort of like a planet that we don't
38 know about. It's always been there but it takes
39 someone to find it; is that the idea?
40 DR. MILLER: Yes, we certainly don't have any data at
41 the present time on whether this is something that
42 is new in terms of that salmon have only recently
43 picked it up or it's something that's been there
44 for a long period of time. That will require some
45 epidemiological work.
46 Q And do you have any understanding so far as to
47 whether this is native or something that's been

1 introduced?
2 DR. MILLER: That kind of understanding will come once
3 we start looking more broadly at where else this
4 viral sequence exists. At the present time, we
5 cannot say.
6 Q Okay. Now, I'm going to ask you questions to let
7 you flush out what you've been saying so far on
8 some points. Firstly, am I correct that your 2011
9 paper was dealing with or addressing 2006 adult
10 returners?
11 DR. MILLER: Yes. I mean in our genomic program, when
12 we first started this program, the real interest
13 in terms of sockeye salmon, and this came from the
14 Pacific Salmon Commission, was the fact that these
15 salmon were dying premature in the river and there
16 was no way to predict what level of mortality
17 different stocks would experience in the river.
18 And the problem with this when it comes to
19 management is that they open fisheries on these
20 fish based on what they assume will be the returns
21 to each of the different river systems.
22 Historically, there was only about 15 to 20
23 percent of fish that would go missing en route to
24 spawning grounds and in the last 15 years or so,
25 it's fluctuated somewhere between 40 percent to 95
26 percent. And it's fluctuated even between
27 different stocks. And so our program was really
28 built on top of Scott Hinch's program and Tony
29 Farrell's programs that were already looking at
30 physiology and radio-tracking to try to understand
31 what might be going on as a way to help provide
32 both a mechanistic understanding for why there are
33 these very high levels of premature mortality but
34 also to hopefully help to provide a tool that
35 managers could use to predict what kind of levels
36 of mortality to expect in those fish.
37 Q Okay. And then it was after you got the 2006 data
38 that you then started looking at smolts about
39 2008, as I understand it, and they're not part of
40 that paper, of course. Can you flush out the work
41 that you're doing with smolts and any conclusions
42 that you've reached with regard to smolts and/or
43 how those conclusions are the same or differ from
44 what you've put in your paper as to the adult
45 returners?
46 DR. MILLER: Yeah, so there's basically two points in
47 the life cycle of salmon that have begun to be of

1 a lot of interest in the scientific community.
2 And these are the times when salmon are
3 transitioning between freshwater to saltwater as
4 smolts and back to saltwater as adults. During
5 these periods of time, we know that there are very
6 high levels of variation in the level of mortality
7 that are experienced and we know that our ability
8 to predict how much mortality will be experienced
9 during those times is quite limited.
10 So there's a lot of focus on early marine
11 ecology by my colleagues, Dick Beamish, Marc
12 Trudel, as well as individuals in the U.S. I
13 developed the program on smolts basically to
14 emulate what we were already doing in adult salmon
15 and obtained a grant from Genome British Columbia,
16 funding from them, as well as Pacific Salmon
17 Commission, DFO and NSERC, along with my
18 colleagues at UBC and other colleagues at DFO.
19 To begin to use genomics as a way to flush
20 out what can the physiology of the fish tell us
21 about what types of things might be undermining
22 their performance? As you've heard previously by
23 other speakers talking about fish health, and I
24 should be clear that my program is not simply
25 about disease. The kind of approach that we're
26 using can flush out things like do the genomics
27 suggest that fish are feeding or not? What is
28 their nutritional status? What is their growth
29 status? Are they prepared for freshwater or
30 saltwater transitions? There's a wide variety of
31 kinds of information that we can get using
32 genomics approaches.
33 And so the idea of this program really was to
34 go out into the ocean with smolts and track their
35 migration in the ocean and ask the question,
36 what's the range of physiological variance in
37 those smolts as they're leaving the rivers in
38 various years? And which physiological signatures
39 might be associated with poor performance? We're
40 very lucky in working with adults that we are able
41 to use approaches like radio-tracking where we can
42 say something about what the fate is of the fish
43 that we're actually studying. In smolts, radio-
44 tracking technology has not yet been developed
45 well enough to be able to do that. And so our
46 questions really are, what's the range in
47 physiology of those smolts? Which of those

1 physiological signatures that we uncover do we
2 expect may be indicative of environmental stress
3 or disease or something of that nature? What do
4 we hypothesize might be the mechanism associated
5 with those signatures?
6 And then the idea of it was this is really a
7 discovery program and we really don't know what's
8 happening to the salmon, why so many of them are
9 dying in some years. And so the thought was that
10 if we could start to use their own physiology to
11 give us indications of what kind of stresses they
12 might be under. This particular signature came
13 out again in the adult study and it could have
14 meant anything. In terms of when we were studying
15 adults, we weren't looking for disease in
16 particular; we were looking for anything that
17 associated with success or lack of success to make
18 it to the spawning grounds.
19 This signature, however, has come out in this
20 program as being the single most powerful genomic
21 signature in everything that we have looked at.
22 This signature is stronger than the genes that are
23 differentiated along the migration route back to
24 the spawning grounds. We see more genes that are
25 affected by this particular signature than are
26 affected when a salmon moves from Queen Charlotte
27 Islands all the way back to the spawning grounds.
28 The number of genes that have to change, and you
29 have to understand salmon are changing
30 physiologically as they migrate, they're
31 senescing, they're maturing and they're
32 encountering all kinds of different environments,
33 et cetera. This signature is more powerful than
34 even that. And this is what has caused us to
35 really focus on this. And it is my view that if
36 we do find that there is a viral pathogen that is
37 causative of this signature, the strength of this
38 signature alone suggests that it is potentially
39 causing disease.
40 Q All right. And has your work and test results
41 that you've obtained with respect to smolts
42 changed your hypotheses in any way from what is
43 set out in the 2011 paper?
44 DR. MILLER: I think it's really strengthened it. The
45 fact that we're observing the same kind of tissue
46 distribution in the presence of this signature, as
47 we observed in adults. When we look at the

1 signature and we look at the genes that overlap
2 between different tissues and between smolts and
3 adults, if you only looked at those overlapping
4 genes, and we have a paper in Paul Pavlidis' lab
5 is sending out on this for adults. But we find
6 that the linkages with viruses become even that
7 much stronger, if you consider only the genes that
8 are overlapping between these tissues and if you
9 consider the same thing for smolts and adults.
10 Basically, we're seeing very similar patterns in
11 both of those life history stages but we're seeing
12 that this is even much more prevalent in smolts
13 than it is in adults and that the signature when
14 smolts enter the ocean becomes even stronger in
15 those fish.
16 And now we're working with this parvovirus.
17 We are doing the work to determine whether or not
18 that is associated or causative of this signature.
19 We also observe the highest intensity, so the
20 highest copy number of the parvovirus in smolts as
21 they're entering the ocean, which is another piece
22 of evidence to suggest that that is an important
23 point in their life history where infectivity and
24 an activity of this virus might be important.
25 Q Okay. Can you just clarify for the Commissioner,
26 you said "ocean" a moment ago and "ocean" appears
27 in various of your writings. What are you meaning
28 by "ocean"? Where is the ocean starting in terms
29 of your writings?
30 DR. MILLER: In the Strait of Georgia. We don't do a
31 lot of work in the estuary but in the Strait of
32 Georgia.
33 Q All right. So leaving the freshwater and going
34 into the salt or vice-versa, Georgia Strait is
35 captured by the word "ocean" in your writings, is
36 it?
37 DR. MILLER: Correct.
38 Q Okay. Can you take a moment and just say,
39 speaking as a scientist, how a hypothesis is
40 developed?
41 DR. MILLER: I touched on that a little bit just a few
42 comments back. Basically, the scientific approach
43 is to take in information, whether that be from
44 your own lab or from publications, and synthesize
45 that information and develop hypotheses to explain
46 that information and then to develop ways of
47 testing those hypotheses. And you might have a

1 number of different hypotheses that one develops.
2 And develop a way, a scientific approach, that
3 would enable you to either validate that
4 hypothesis as being correct or refute that
5 hypothesis as most likely being incorrect.
6 And this is the process that we work with
7 everyday. It can be little things that are new
8 hypotheses or it could be very large things. And
9 in the process, I think you can see I've provided
10 a timeline in association with this inquiry, to
11 provide information about how we were thinking
12 about our various discoveries over time and why we
13 generated specific hypotheses, on what basis of
14 what data that we obtained made us take some
15 different turns in the research that we were
16 doing. I have to say that the hypothesis that
17 this particular signature is associated with viral
18 activity has never changed.
19 MR. TAYLOR: All right. Thank you. I'm going to cover
20 off a couple of documents and mark them as
21 exhibits before we proceed into questions. Could
22 you please go to Tab 25 of Canada's documents, Mr.
23 Lunn? Or Commission's documents, I'm sorry.
24 Q I think what you're going to see is a document you
25 prepared come up, Dr. Miller. Do you recognize
26 that?
27 DR. MILLER: Yes, I do.
28 MR. TAYLOR: Can you just scroll to the very end, Mr.
29 Lunn, for a moment? I just want Dr. Miller to see
30 what's at the end. Little before that end, I
31 guess. Somewhere there's a date near the end.
32 Just keep going up, I think. No, no.
33 DR. MILLER: Down.
34 MR. LUNN: DD.
35 MR. TAYLOR: DD is fine. It says in July 2011 and then
36 if you go back to the beginning, Mr. Lunn.
37 Q You'll see that it says there "last revised May
38 19, 2011". What's the true date of this document?
39 DR. MILLER: I've been caught again on my dating issue.
40 I take documents and I modify them and sometimes I
41 forget to change the date at the top. So I
42 prepared this, I believe, at the end of July/early
43 August.
44 Q Of this year?
45 DR. MILLER: Of this year.
46 Q And it is what it says.
47 DR. MILLER: Or I revised it. I did prepare it

1 originally in May.
2 Q All right. I see. And then you updated it. And
3 it is what the title says, a timeline of genomic
4 research, is it?
5 DR. MILLER: Yes, this was suggested to me by Laura
6 Richards, that it would be much easier to sort of
7 understand our thinking and the changes in our
8 thinking if I put together a timeline which showed
9 when we discovered various things and how that
10 resulted in some of the hypotheses that we put
11 forward.
12 MR. TAYLOR: All right. May that be the next exhibit,
13 please?
14 THE REGISTRAR: It's Exhibit 1517.
15
16 EXHIBIT 1517: Timeline of Genomic Research
17 relating to the Mortality-related Genomic
18 Signature Hypothesized to be associated with
19 a potentially Novel Virus
20
21 MR. TAYLOR: And if you'd go to Tab 10 in Canada's list
22 of documents, that is already an exhibit already,
23 I think, although I don't know the number.
24 MR. LUNN: 1513.
25 MR. TAYLOR: Pardon me?
26 MR. LUNN: 1513.
27 MR. TAYLOR: Okay. This is Exhibit 1513.
28 Q If we go to page 13 of Exhibit 1513, you deal
29 there with parvovirus but also retrovirus.
30 Retrovirus is what?
31 DR. MILLER: Retrovirus is an RNA virus. Kyle might be
32 better describing the actual viral families but
33 they tend to be oncogenic viruses, which means
34 that they tend to be associated with cancer. They
35 have an ability to insert themselves in the host
36 genome and become endogenous, which is a special
37 feature of retroviruses but it's not the only
38 viral family that does it but it certainly is the
39 one that's most well-known for that.
40 Q Okay. And I probably should have asked, Dr.
41 Garver, because you're the virologist, but do you
42 want to add to that or describe retrovirus?
43 DR. GARVER: No, that's quite sufficient. It is an RNA
44 virus and one of the key features and Dr. Kent
45 alluded to this is so they transcribe their RNA
46 into DNA and they use a special enzyme called
47 "reverse transcriptase" so one of the common

1 things to look at for retrovirus is known as an
2 "RT, reverse transcriptase activity". And so
3 that's the only other addition.
4 Q Okay. There's two terms that we see in some of
5 the writings and I'll ask this of whichever one of
6 you is the right person to answer the question.
7 The two terms are "molecular genomics" and
8 "functional genomic studies". Is one of you able
9 to give a sort of one or two-sentence answer or
10 definition of what each of those is?
11 DR. MILLER: Functional genomics pertains to gene
12 expression. And molecular genomics can pertain to
13 a lot of different areas of genomics but I think
14 the context, if I have use that terms, has been
15 more sequencing level genomics.
16 Q All right. If we turn to Tab 22 of Commission's
17 documents, which is also Exhibit 1512 now, you
18 will see the document entitled "Hypothesis". This
19 is something that you prepared, Dr. Miller. I'm
20 not sure if you said when. You might have said
21 this is for the June 2010 PSC symposium, is it?
22 DR. MILLER: Correct.
23 Q Okay. You begin this document by pointing out
24 that in 2006 you first raised up what we're now
25 talking about at a meeting in Oregon. You've
26 spoken to some of this before but was there an
27 instigating event or reason why you started into
28 this line of work or this area?
29 MR. MARTLAND: I'm just going to clarify our
30 understanding is it may be Nanaimo as opposed to
31 Oregon, if that assists.
32 MR. TAYLOR: It's in the document, I think, but...
33 DR. MILLER: Oregon? Definitely Nanaimo.
34 MR. TAYLOR:
35 Q Okay, that's fine. In any event, in 2006, you
36 first talked about the work that you've now been
37 giving evidence about, as I understand it?
38 DR. MILLER: Correct. Our program really started in
39 around 2005. We started purchasing equipment in
40 about 2004 but our genomics program got up and
41 going in 2005. And as I've said, the program was
42 developed in response to the lack of
43 predictability on salmon that in the return
44 migration salmon that will successfully make it to
45 the spawning grounds and salmon that would
46 successfully spawn. It grew from that to working
47 on smolts because there was a lot of interest in

1 that early marine mortality and what might be
2 undermining performance of salmon in that early
3 marine period. Now, that does not just extend to
4 sockeye salmon. Early marine mortality has been
5 increasing in chinook and coho salmon as well and
6 I know that Dr. Beamish has already spoken to the
7 Commission about that.
8 And so I developed a collaboration with Dr.
9 Beamish and Dr. Trudel whereby we were able to
10 obtain samples from their very extensive ocean
11 cruises that are conducted every year in the
12 Strait of Georgia and also into the high seas and
13 with David Patterson, who is an absolute
14 instrumental biologist here in DFO, who runs the
15 Environmental Watch program and has from the very
16 beginning of our program done all of the
17 collections in the Fraser River and also put
18 people in to do the collections on the smolts. So
19 the program was developed in response to a lack of
20 predictability.
21 The fact that the escapement models that are
22 used in salmon management are not very accurate
23 and so there's a lot of interest in (a) can we
24 find ways of modifying those models with new
25 information that might increase their accuracy?
26 My program has been working in the area of salmon
27 genetics for a lot of years and when I came into
28 that program about 19 years ago, we were trying to
29 develop a program to do genetic stock ID. And
30 many of you might have heard of that. We have
31 developed an incredible program that is used all
32 the time now by managers for genetic stock ID.
33 And the management of sockeye salmon is based on
34 information that we provide on a real-time basis
35 on what stocks are present in a given fishery.
36 The idea behind this program is managers can
37 now know if they go out and catch fish in the
38 marine environment what stocks of fish are present
39 and they can make management decisions so that
40 they can minimize impacts on stocks in need of
41 conservation and maximize their targeted
42 exploitation on stocks that can handle
43 exploitation. The problem was that they still
44 didn't know how many fish were going to make it
45 back to spawning grounds.
46 And so the idea was if we could develop using
47 genomics a program that piggybacks with that, that

1 looks at the health and condition of the fish, and
2 adds that as another piece of information that
3 managers can have, that might add greater
4 predictability to their escapement models that
5 they could not only know when they're out if
6 they're looking at returning adults, they could
7 not only know what stocks are present but what's
8 the probability that those fish are actually going
9 to survive to spawn?
10 That was what spurred the development of this
11 program and it further developed into the smolt
12 program in discussing this program with colleagues
13 and the need for more information about health and
14 condition of smolts in the early marine
15 environment.
16 Q And that remains the driver for the work you're
17 doing, I take it?
18 DR. MILLER: That is absolutely the driver. And this
19 is a discovery program. We're using genomics to
20 discover what kind of factors might be
21 exacerbating their performance.
22 Q And as I understand it, it's fundamental to
23 understand that this is a work-in-progress with
24 much more to be done and learned?
25 DR. MILLER: Yes, I think it's a fairly unusual process
26 to have this level of scrutiny on a program that
27 is just in complete active research mode. And
28 it's interesting but yes, this is absolutely
29 research-in-progress. And we are taking many
30 different angles to this research as we make new
31 discoveries and as what we're doing with Kyle in
32 terms of the disease challenge work.
33 Q All right. In the document that's up on the
34 screen, Exhibit 1512 I think it is, if you turn to
35 page 3, about halfway down there's a heading that
36 starts with "Signature" and there's a bullet under
37 that to do with affected tissue and under that it
38 says "no muscle involvement". I understand that's
39 significant and allowed you to rule out something.
40 And I'm not sure if I should be asking you, Dr.
41 Miller. This is your document. Or whether Dr.
42 Garver is the one on this. But one or both of
43 you, what's the significance about not seeing this
44 in muscle?
45 DR. MILLER: Well, it isn't highly significant. It's
46 significant that we don't see it in absolutely
47 every tissue that we look at. And you know, where

1 that comes into play is that most viruses and most
2 pathogens have specific tissues that they affect
3 and Kyle should be the better one to speak to this
4 but many viruses have a specific target tissue
5 that they're generally seen in first and then they
6 may move into other tissues at various stages of
7 infection. The fact that we haven't picked up
8 this signature in muscle tissue, I mean there are
9 viruses that affect muscle tissue. That doesn't
10 mean anything one way or the other about this
11 being a pathogen or not being a pathogen but we
12 also don't see it in hypothalamus tissue either.
13 It just means it's not in absolutely every tissue
14 in every individual.
15 Q And Dr. Garver, in terms of significance attached
16 to it not being in muscle, do you have anything to
17 say on that?
18 DR. GARVER: No, I think Kristi covered that pretty
19 well. As far as viruses, they do have kind of a
20 life cycle or an infectious cycle of how they
21 progress through a host. And it ranges from the
22 initial infection, which could be epithelial cells
23 primarily with fish, but it could be different.
24 And then it could go through a viremic state which
25 then, as a viremic host, it's pretty much
26 throughout the fish.
27 It's in the blood and then multiple tissues
28 attach to the circulatory system and then either
29 results in death of the host or may regress if the
30 host is able to fight it off. And sometimes it's
31 cleared and sometimes it actually even remains in
32 tissues in a latent state or a carrier state. So
33 yeah, from determining whether it's in the muscle
34 or not, I don't think we can really conclusively
35 say that this is linked to a pathogen or not.
36 DR. MILLER: Okay. Can I just add to that? I'm
37 actually looking at what's in front of me. I
38 didn't actually look at it carefully. The point
39 in this particular part of the document was, if
40 you read the top, that this signature is not
41 consistent with the general stress response, sea
42 lice infection or parvicapsula infection because
43 this is a question that I was often asked when I
44 would talk about this work and about this
45 signature, could this simply be a signature
46 associated with parvicapsula? So now I see the
47 significance of that in this particular document

1 is that sea lice affects muscle tissue.
2 Sea lice will bind to the skin and will cause
3 a reaction in muscle tissue. And so what this was
4 basically saying was there's no muscle
5 involvement. We don't see the signature in muscle
6 tissue. Really, the strongest part of what this
7 argument shows is where the fish are affected. If
8 this signature were something that was a response
9 to sea lice then it shouldn't be emanating from
10 the freshwater environment because salmon don't
11 pick up sea lice until they enter the marine
12 environment. So it is highly inconsistent with
13 this being a response to sea lice. It's also not
14 consistent with a parvicapsula infection because
15 we see the signature as far as the Haida Gwaii in
16 returning adult salmon. And returning adult
17 salmon pick up parvicapsula when they enter the
18 Fraser Estuary. And so where the tissues were
19 affected, it has something to play. We don't
20 expect there to be a strong involvement of the
21 brain, for instance, for sea lice and we do see
22 very strong involvement of the brain associated
23 with this signature. But I think that the most
24 important point here was where we see the fish
25 affected.
26 Q All right. Did one or both of you put your mind
27 to whether the signature had any relationship to
28 well-known pathogens such as IHN or ISA and take
29 steps to rule them in or out?
30 DR. MILLER: We conducted screening for all of the
31 viruses that were in B.C. that had molecular
32 markers for them so that we already had sequence
33 information for. We applied the molecular markers
34 that other labs had already developed to our
35 samples and we found that none of those known
36 characterized viruses were (a) present in any kind
37 of prevalence like we have observed this
38 signature, or (b) associated with fish that
39 carried and didn't carry the signature. So in the
40 early days, in fact, before we wrote the Science
41 paper, had already discounted that. We couldn't
42 find a virus or intercellular pathogen because we
43 also tested a variety of intercellular pathogens
44 that was correlated with the presence of this
45 signature.
46 Q And is the viruses that were considered the ones
47 that Dr. Kent reviews in his paper?

1 DR. MILLER: Yes.
2 Q All right.
3 DR. GARVER: I can add one thing to that as well. And
4 I alluded to it earlier.
5 Q Add as many as you wish, Dr. Garver.
6 DR. GARVER: So again, this genomics profiling is not a
7 definitive diagnostic and to be able to rule out
8 other signatures of viruses, you need to know
9 those signatures. And there has been some genomic
10 work done. Kristi, in particular, has worked on
11 IHN and has established a possible signature for
12 IHN. However, there hasn't been much work outside
13 of that to the other pathogens. So definitive
14 signatures for ISA, VHS, all these other pathogens
15 are not really well-known for fish. So to apply a
16 signature in this case may not necessarily be
17 appropriate without that information.
18 DR. MILLER: I don't believe that's actually what we
19 were trying to do. What we identified from this
20 signature was that it contained numerous elements
21 that were consistent with known processes that
22 were affected by viruses. The specifics about
23 what virus it was really was when we took the
24 molecular approach to look at the presence of
25 known viruses and known viral sequences. I don't
26 believe that I ever went and looked at this
27 signature and asked, is this an IPN virus based on
28 the signature? All we did with the signature was
29 suggest that this was virally mediated and that
30 there were components of the signature that were
31 really highly similar to the types of things that
32 could be affected by retroviruses but that was as
33 far as that went.
34 Q Were MRS-positive tissues tested for ISA or other
35 viruses?
36 DR. MILLER: We did test for ISA but we did not have a
37 positive control for ISA. Those are tightly held
38 because of the worry about infection. But we did
39 test with ISA primers.
40 Q All right. Now, Dr. Garver, you have already
41 testified to some of your work and involvement in
42 the work of Dr. Miller. Is there anything more
43 that you want to add to that in terms of your role
44 and the role of your lab in Dr. Miller's work?
45 DR. GARVER: I think the main point is, in establishing
46 now once we have a molecular diagnostic for the
47 parvovirus and so now the real question is, is it

1 infectious and does it cause disease? And if so,
2 what is the pathology associated with that
3 disease? And then there's many other questions in
4 relation to that. If we do prove it's infectious
5 then what are the predisposing factors for
6 disease? In other words, if you change the
7 temperature of the water, does that predispose a
8 fish to subsequent infections, if infection does
9 occur to the parvovirus, or does smolting of the
10 fish increase infection, or does multiple
11 pathogens infecting that fish, does that make it
12 more susceptible? So there's a whole line of
13 questions to go down now but we really need to
14 establish, is this sequence that we have right
15 now, is it an actual agent and is it infectious to
16 fish?
17 Q So with those questions, what is the current state
18 and what are the next steps in timing for that
19 work?
20 DR. GARVER: As I alluded to earlier, we just started a
21 challenge yesterday. This is to determine the
22 infectious nature of this sequence that we have
23 right now.
24 Q And do you have a timeline for this work?
25 DR. GARVER: It typically takes up to several months.
26 So we hope to have some answers maybe within two
27 months or so.
28 Q And you don't know what the answers are, of
29 course, but what sort of answer? What's the topic
30 the answer would be on? What will you know then
31 one way or the other?
32 DR. GARVER: Well, we'll have an idea under the
33 challenge conditions that we're using whether it's
34 infectious. If we don't see transmissibility
35 through this challenge that we're doing then we
36 might not just have what could be possibly
37 happening in nature. So we need to then explore
38 different challenge scenarios. But ultimately, we
39 hope to have after two months a good idea of
40 whether this is a transmissible agent or not.
41 Q So it sounds from what you're saying that as we
42 move into the year 2012, you're going to have
43 advanced some distance in the work you're doing as
44 part of this genomic signature?
45 DR. GARVER: Yeah, once you have a challenge model to
46 work with for this virus and take it down into the
47 lab and actually start manipulating different

1 variables, then you really progress your science
2 as far as disease progression and whether this is
3 linked to disease.
4 Q Let me just -- sorry. Dr. Miller?
5 DR. MILLER: At some point, I'd just like to add a few
6 comments about parvoviruses.
7 Q All right. Go ahead.
8 THE COMMISSIONER: Mr. Taylor, I wonder if we could
9 take the lunch break and get into parvovirus after
10 lunch.
11 MR. TAYLOR: Sure.
12 THE REGISTRAR: The hearing is now adjourned until 2:00
13 p.m.
14
15 (PROCEEDINGS ADJOURNED FOR NOON RECESS)
16 (PROCEEDINGS RECONVENED)
17
18 THE REGISTRAR: The hearing is now resumed.
19 MR. TAYLOR: Thank you, Mr. Commissioner.
20
21 CROSS-EXAMINATION BY MR. TAYLOR, continuing:
22
23 Q We're going to come to parvovirus in a second
24 here. I just want to take a few minutes to put
25 some documents in as exhibits. I'm mindful of the
26 time. So I'm going to ask you, witnesses on the
27 panel, if you can identify a document, whether you
28 prepared it, what it is, and the approximate date,
29 and then put it in as an exhibit. And I think in
30 the interests of time, have to leave it there.
31 Canada's Tab 1, this is a question of Dr.
32 Garver. Do you recognize that, Dr. Garver?
33 DR. GARVER: I do, yes.
34 Q Your mike's not on, I think.
35 DR. GARVER: I do recognize that document.
36 Q What is that?
37 DR. GARVER: This is a presentation that I gave at the
38 April DFO workshop to give updates on hypotheses
39 presented at the Pacific Salmon Commission
40 workshop.
41 Q Okay. The April 2011, DFO meeting.
42 DR. GARVER: That's correct.
43 MR. TAYLOR: All right. May this be the next exhibit,
44 please.
45 THE REGISTRAR: Exhibit number 1518.
46
47

1 EXHIBIT 1518: Garver, Hypothesis: Diseases
2 in freshwater and marine systems are an
3 important contributor to the Fraser sockeye
4 situation, April 2011
5
6 MR. TAYLOR:
7 Q Then if we go to Canada's Tab 8, Mr. Lunn, please.
8 Do you recognize that, Dr. Garver?
9 DR. GARVER: I do, yes. This is again a presentation
10 that I gave at a Western Fisheries Research
11 conference, Fish Health Disease conference. I
12 believe that was in Utah.
13 Q All right.
14 DR. GARVER: I can't recall the date.
15 Q Is this just what it says there, some of the
16 technician methodology that was used by you in
17 some of the work you've been doing?
18 DR. GARVER: Yeah, it's some of the research that I've
19 been doing with Dr. Tang and the technicians in my
20 laboratory to validate the microarray detection
21 method I spoke of for fish viruses.
22 MR. TAYLOR: Thank you. Then if we go to Canada's Tab
23 11, please.
24 THE REGISTRAR: Did you wish to mark Tab 8 first?
25 MR. TAYLOR: Oh, I'm sorry. I'm moving too fast,
26 aren't I. Next exhibit, please.
27 THE REGISTRAR: Tab 8 will be marked as Exhibit 1519.
28
29 EXHIBIT 1519: Garver et al, Microarray-based
30 Detection of Fish Viruses
31
32 MR. TAYLOR: Thank you. Tab 11, Mr. Lunn.
33 Q Dr. Miller, do you recognize that, and what is it?
34 DR. MILLER: This is a presentation, a private
35 presentation I gave at the internal DFO workshop
36 in April of 2011.
37 Q Thank you. And that's contrasting with the 2007
38 and 2008 results that you spoke about earlier, is
39 it?
40 DR. MILLER: Correct.
41 MR. TAYLOR: Thank you. And then if we move to Tab 12,
42 please, of Canada's documents. Oh, I'm sorry, I
43 forgot to mark it again. May that be an exhibit,
44 please.
45 THE REGISTRAR: That will be marked as Exhibit 1520.
46
47

1 EXHIBIT 1520: Miller, 2007 versus 2008
2 Genomics Contrast Study, April 2011
3
4 MR. TAYLOR:
5 Q And Tab 12, please. Do you recognize that, Dr.
6 Miller? Do you need to see more of it?
7 DR. MILLER: Yes, I do. This is the talk I gave at the
8 Pacific Salmon Commission in June of 2010.
9 MR. TAYLOR: All right. And may that be an exhibit,
10 please.
11 THE REGISTRAR: Exhibit 1521.
12
13 EXHIBIT 1521: Miller, Hypothesis: Genomic
14 studies suggest that some disease has
15 infected sockeye and has become an important
16 contributor to the Fraser River sockeye
17 situation, June 2010
18
19 MR. TAYLOR:
20 Q Now, just before lunch, Dr. Miller, you were going
21 to explain or elaborate on parvovirus. Could you
22 take a couple of moments to do that right now, and
23 in regard to that, may we have, please, Exhibit
24 1513, which is also Canada's Tab 10, page 12.
25 DR. MILLER: Can we move to page 11 first. Oh, okay,
26 sorry, it was page 10. Okay, go back to 12,
27 sorry. I'm sorry about that.
28 Q Do you want to have the -- do you want to have the
29 full document in front of you?
30 DR. MILLER: The one on the contrast between -- between
31 retroviruses and --
32 Q Oh, 13.
33 DR. MILLER: Oh, it was 13, I'm sorry.
34 Q Page 13.
35 DR. MILLER: Okay. I know I was asked about
36 retroviruses and what retroviruses are, and in --
37 certainly one of the stages in my hypotheses about
38 this MRS signature was that it could be elicited
39 from a retroviral-like infection. We didn't end
40 up identifying a retrovirus in association with
41 that signature, but we did identify a parvovirus.
42 And I just wanted to point out that there are some
43 very interesting similarities between the two,
44 despite the fact that one is a DNA virus and
45 another is an RNA virus.
46 And one of which is parvoviruses can insert
47 their genetic material into the host genome. This

1 is not something that is as well-known. We have
2 done the work to establish that this is not the
3 case for the sequence that we have. If they've
4 inserted their genome into their host, every cell
5 would have the same complement of DNA and we would
6 see this virus in every cell within an individual,
7 and we do not see that.
8 Interestingly, one of the most powerful
9 aspects of the signature is in terms of a stress
10 response, is a host DNA damage response. And both
11 of these viral families require the elicitation of
12 a DNA damage response in order to complete
13 replication. And so that's something they have in
14 common.
15 They both are associated with very strong
16 immunosuppression of the host.
17 They both actually can cause leukemia-like
18 disease.
19 Retroviruses obviously contain the leukemia
20 viruses, which we know to be causative of
21 leukemia, but there is a plethora of studies over
22 the last 20 years about the role of parvovirus B19
23 in humans, in leukemia-like disease, and its role
24 in exacerbating the outcome for people with
25 leukemia. But there are some papers out that show
26 that you can actually get a leukemia-like response
27 from a parvovirus, which is something we also
28 found in our data.
29 Both have been linked with cancer, but while
30 retroviruses can cause cancer, parvoviruses are
31 actually anti-cancer activities. So they target
32 rapidly dividing cells to facilitate their
33 reproduction, and so they have been used -- one
34 kind of human one has been used to fight brain
35 tumours, actually.
36 And they can both be involved in latent
37 infections. And both viral families are known for
38 remaining inactive for years to wait until the
39 right conditions to begin to replicate and cause
40 disease.
41 If you can just go to the previous slide. I
42 won't spend a lot of time on this.
43 But in terms of parvoviruses, some of the
44 best known parvoviruses are parvoviruses in dogs,
45 and they can have decimating effect on young -- on
46 puppies and young dogs.
47 And there's a parvovirus that is quite

1 virulent in humans called B19. It's associated
2 with fifth disease in children, but it requires
3 hematopoietic cells to divide, and it's associated
4 with severe anaemia. Again, this is -- anaemia is
5 something that comes up over and over again in
6 some of the observations that we have in salmon,
7 not me personally, but people have been observing
8 anaemia in salmon. And parvoviruses can actually
9 cause anaemia in a variety of different organisms.
10 I think one of the most interesting things
11 about this family of viruses is not only that they
12 require rapid -- rapidly dividing cells to
13 facilitate their own reproduction, but they can be
14 oftentimes stimulated by stress. And there's a
15 number of studies that have shown that one can
16 induce, if you have cells that are not rapidly
17 dividing, one can induce the proliferation of
18 parvoviruses by simply stressing the cells.
19 And so I think this is interesting in the
20 context of whether or not a virus like this could
21 become more active and elicit more disease in a
22 situation where salmon are known to be highly
23 stressed, when they go between freshwater and
24 saltwater and return back into the freshwater
25 environment. That at this point I would say is
26 speculation, but it is -- it is something that I
27 am quite interested in terms of this particular
28 viral family.
29 Q Okay, thank you. Dr. Garver, before lunch you
30 gave some evidence about the lab studies that you
31 have done, and then moving on, lab studies that
32 you're currently embarking upon. Laboratory
33 studies are in a controlled setting, of course.
34 Can you clarify what next steps you see beyond
35 those laboratory studies that you're about to take
36 on right now?
37 DR. GARVER: Yeah, sure. I guess to back up just a
38 little bit, I'll give you some thinking, rationale
39 for our thinking on why we're progressing to
40 laboratory studies. This is not a typical disease
41 investigation. Typically when we approach a
42 disease investigation, it's usually because we
43 have some -- we actually have a disease or a
44 pathology or even more specifically, mortality
45 associated in a population.
46 So if there's mortality, if there's a die-off
47 event in fish, we'll go out and then run a disease

1 diagnostic on those fish to identify the
2 etiological agent that might be responsible. And
3 to do that, that involves traditional methods of
4 culturing, culturing the pathogens, and doing
5 histology to identify the pathology associated.
6 And that's important, because once you have the
7 histological marker or signature of that disease,
8 then you can actually see what damage is being
9 done and get an idea of the impact of that
10 pathogen and consequently the disease on the
11 population. And so in this case, it's quite a bit
12 of a reverse scenario.
13 And we first -- Dr. Miller first identified a
14 genomic signature that might be linked to a
15 negative impact on the fish. And so inferring
16 upon that genomic signature, it was found that
17 there could be a possible virus associated with
18 it. I grant there was no mortality associated
19 with that, or a disease associated with it, it's
20 now a sequence of a virus. And so we have to
21 identify is that an infectious agent and does it
22 cause disease. And so to do that, you then take
23 it back into the laboratory and do the
24 transmission studies. So that's really the key on
25 where we're going.
26 But it's nice to take into a laboratory
27 study, because then you can obviously control the
28 setting, control the parameters. And it has to be
29 repeated, it has to be at least confirmed that you
30 can do that over and over again. And so in that
31 regard, once you establish the fact that it is
32 infectious, it's all under the context that it's
33 in the laboratory.
34 And then you, then once you have histological
35 markers, then you can go out in the wild and start
36 looking at it, using histological markers, using
37 the molecular techniques that Dr. Miller is
38 establishing, getting viral loads in these and
39 really assessing is there an impact due to the
40 infection of this pathogen on a population.
41 Q All right. And my final question, then, is of
42 you, Dr. Miller, and Dr. Garver has just spoken to
43 some of this, but -- a lot of this. Do you have
44 anything to add to what's been said there about
45 the approach you're embarking on and doing versus
46 the traditional approach to studying a disease.
47 DR. MILLER: Yes. First of all, I would correct one

1 thing that Kyle said, that we -- that it's correct
2 that we didn't have observable mass mortality
3 events, and we don't have observable mass
4 mortality events in the ocean. And we do have
5 mortality in fish when they come back in the
6 river, but we don't generally observe that
7 mortality unless they're dying at the spawning
8 grounds. When we originally identified this
9 signature, it was associated with mortality in
10 that initial study that's in the *Science* paper.
11 But, no, I think it's an important point.
12 And you just have had heard two days of talks or
13 of a panel of disease experts who have basically
14 suggested that it is nearly impossible to study
15 disease in wild salmon because we can't observe
16 their mortality. And if we use the classical
17 approaches of only -- only studying disease where
18 we can observe massive mortality events, and
19 assuming that we're going to pick up all diseases
20 by only looking at massive mortality events in
21 hatcheries, in one environment, in the freshwater
22 environment where we can see these sorts of
23 things, I think it's clear, given the lack of data
24 that exists in terms of diseases in sockeye
25 salmon, that that approach simply hasn't worked.
26 And that the approach that we're taking is a
27 different approach to -- and again we didn't set
28 out to look for disease, but it is almost
29 backwards of what -- of what a normal approach to
30 studying disease would be.
31 In normal, microarrays are actually used in
32 the human medical world all the time. They're
33 used to study disease and host response to a wide
34 variety of pathogens and as well as drug
35 therapies. And that's the last thing one does in
36 order to figure out what's the best, what's the
37 best prophylactic treatment, what's the best
38 vaccine treatment, how do we get an effective
39 response so that animals are less prone to disease
40 from specific pathogens.
41 You know, we flipped that on the head and
42 said, let's just look at what the animals are
43 telling us. Let's look at what the physiology of
44 the animals can tell us about what's affecting
45 them, and then we'll go back and hypothesize as to
46 what could be causing that, and then we'll go back
47 and do the laboratory studies to validate those

1 hypotheses, and to validate whether or not one
2 can, at any stage in the development of salmon,
3 elicit disease and mortality associated with what
4 we now have as a candidate virus.
5 MR. TAYLOR: All right, thank you. Thank you, Dr.
6 Garver, Dr. Miller. Those are my questions, Mr.
7 Commissioner.
8 MR. MARTLAND: Thank you. Mr. Commissioner, next I
9 have counsel for the Province at 55 minutes.
10 MS. CALLAN: Mr. Commissioner, Callan, C-a-l-l-a-n,
11 initials T.E., appearing on behalf of Her Majesty
12 the Queen in Right of the Province of British
13 Columbia.
14
15 CROSS-EXAMINATION BY MS. CALLAN:
16
17 Q Dr. Miller, how was the common genomic profile
18 defined, and specifically the MRS?
19 DR. MILLER: I'm not sure what your question is.
20 Q Specifically is it a specific cluster of genes?
21 DR. MILLER: Oh, okay, I'm sorry. Yes. The signature,
22 actually, when we first uncovered the signature we
23 had simply run a *t* test between 12 fish sampled in
24 a marine environment but made it to the spawning
25 grounds, and 12 fish that went missing. That was
26 the very first time we uncovered that signature.
27 However, we added more fish to our study. We did
28 a study in the freshwater environment, as well,
29 and when we added those additional fish, a simple
30 *t* test didn't pull it out very well.
31 One of the reasons for that, and something
32 that has to be recognized is that in return
33 migrating salmon, there is not likely a single
34 cause of all mortality that occurs in the river.
35 And so we recognize at a very -- at the very
36 outset that it may be difficult to simply assume
37 that all fish that die in the river die of the
38 same thing, and that really wasn't our assumption.
39 We were looking for genomic signatures that were
40 associated with poor performance, not necessarily
41 causative of all mortality in the river.
42 We found that we were able to identify this
43 signature with principal component analysis, and
44 we've used principal component analysis as a
45 method to identify the major physiological
46 trajectories in the data. And then we looked at
47 correlations between success and lack of success

1 in terms of migration along each of the principal
2 components in principal component analysis.
3 I know that's very technical, but you asked.
4 Q And I get what I asked. I understand from your
5 earlier evidence this morning that you stated that
6 the power of the test strength of the signature
7 alone might be evidence of disease. You would
8 agree, however, that the signature alone will not
9 cause disease, although it may be a marker?
10 DR. MILLER: The signature alone will not cause disease
11 in and of itself. The signature indicates a lot
12 of activities at a cellular level when salmon
13 reach the freshwater environment. The signature
14 does not cause the disease. Whatever's causing
15 the signature could cause disease.
16 Q Now, I understand earlier you were talking about
17 principled and unprincipled. Is that the same as
18 supervised and unsupervised analysis?
19 DR. MILLER: No. Principal component analysis is an
20 unsupervised analysis. So it's a way to simply
21 let the data speak for itself and tell you what
22 are the major trajectories in the data.
23 A supervised analysis is if we were to run a
24 *t* test or an ANOVA, and say I want to contrast
25 what genes are being turned on and off in this set
26 of individuals, compared to this other set of
27 individuals. So that is one of the analyses that
28 we did try, which was to simply run a *t* test,
29 comparing fish that made it to the spawning
30 grounds and fish that didn't.
31 But in order for a *t* test to be -- to resolve
32 anything very powerfully, you have to have -- it
33 depends on your sample sizes, but you have to
34 basically have, you know, a single signature
35 that's associated with whatever you're looking
36 for.
37 Q So to summarize it, in your ocean-tagging study,
38 the supervised analysis was not statistically
39 significant.
40 DR. MILLER: In our first -- in our first analysis of
41 the ocean-tagging study, the first fish we ran we
42 did actually get a significant *t* test. However,
43 when we added more fish to that analysis, because
44 we were just -- we were just looking -- we were
45 looking, actually, at muscle tissue and gill
46 tissue at the time. And we found that we didn't
47 really get any signal associated with survivorship

1 in muscle tissue, and but when we did our first
2 analysis of the gill tissue, we actually did.
3 When we added more samples, it became more
4 obscure. And but we did then pull it out with PCA
5 analysis.
6 Q Now, in the principal component, or the
7 unsupervised analysis, you did find gene
8 expression patterns, and this was the basis for
9 your statement in Exhibit 558, your paper that 60
10 percent of the fish contained a gene expression
11 signature in seawater greater than 200 kilometres
12 from the river that was predictive of an in-river
13 fate.
14 DR. MILLER: That was -- it was associated with poor
15 performance in the river.
16 Q Okay. So, Mr. Lunn, if we could turn to the top
17 part of Figure 1A of Exhibit 555 -- 558. It's
18 page 214, which would be the second page. How
19 many fish are in the group with the mortality-
20 related signature in Figure 5A?
21 DR. MILLER: You're not showing 5A.
22 Q Oh, sorry, 1A.
23 DR. MILLER: Well, I'd have to read through the paper
24 again. Okay. So over all of those fish, there's
25 somewhere around 40 fish in A -- is A what you're
26 talking? I'd have to actually look at the paper
27 to remember the exact numbers. Do you want me to
28 look at the paper? Which tab is this?
29 Q This is --
30 DR. MILLER: It's outlined in the paper. Which tab is
31 this?
32 MR. TAYLOR: It's 18 in the Commission's binder.
33 MS. CALLAN:
34 Q I can suggest to you that it was 10, but if you
35 could --
36 DR. MILLER: Oh, I'm sorry. I misunderstood. I
37 thought you meant in the whole study.
38 Q No, just speaking about the fish with the
39 mortality signature in figure 1A.
40 DR. MILLER: Okay, where we've demarcated it. Yes, I
41 believe there's ten.
42 Q Now, when I count the two groups, it looks like
43 there's samples of five and five, and I understand
44 from speaking with others that that's actually
45 mistake, and it was six and four.
46 DR. MILLER: Yes. There was -- we've had a discussion
47 about this with Gary Marty. The top bar that

1 demarcates survivors and upper river morts, there
2 was a glitch in the way that that was put on, and
3 there's one -- there's one fish that died that's
4 missing on the -- on the left-hand side.
5 Q But certainly for the purposes of your analysis,
6 you didn't use five and five, you used six and
7 four, so it's just a glitch.
8 DR. MILLER: No, no. I know. Gary Marty has had all
9 of the data and redone all of the analyses, and we
10 noticed that we had a glitch on the top bar.
11 Q Okay. So for this purpose of my next set of
12 questions, it's going to be about determining
13 whether or not a diagnostic test can be derived
14 from this, because I'm anticipating my friends
15 might recommend that we could try to test for
16 these fish using the genomic signature. So that's
17 going to kind of form where I'm going.
18 So essentially 40 percent of the time you
19 would be -- you would be incorrect if you tried to
20 predict based on this test?
21 DR. MILLER: "Forty percent of the time you would be
22 incorrect", I think there's something that is in
23 the *Science* paper that I need to explain. And
24 that is that what we found with this signature,
25 and it makes obvious sense when you think about
26 it, is that the individuals on the extremes of
27 this signature, the individuals that are most
28 highly affected, which are those on this -- on
29 this figure that would be way to the left-hand
30 side, as you go on this, on this almost continuous
31 gradient, you have individuals that are highly
32 affected, individuals that are something in the
33 middle that don't really have any effect and, you
34 know, have -- and then you have individuals on the
35 other side.
36 If you envision this as individuals having
37 exposure to a flu bug, and having the flu, and
38 having pneumonia, right. So you have a very
39 different probability of survival if you have
40 pneumonia than if you simply were exposed to the
41 flu bug. And this could be, it doesn't even have
42 to be a disease scenario. If you had individuals
43 that were starving and you were nutritionally
44 deprived, and some that were well fed, you would
45 only expect that there would be an effect on
46 survivorship on the ones that are starving, not
47 the ones that are just nutritionally deprived.

1 And so this is the way that we have looked at
2 this data, and others have, as well, in other
3 kinds of studies. What we're looking for are the
4 physiological extremes. And so you're absolutely
5 right, there is no predictive power for fish that
6 are intermediate in this signature.
7 Q Now, Dr. Garver, you have experience in developing
8 diagnostic tests for developing viruses.
9 DR. GARVER: That's correct.
10 Q Would you use or recommend a diagnostic test from
11 this data.
12 DR. GARVER: To determine a virus?
13 Q Correct.
14 DR. GARVER: A specific virus from a genomic signature?
15 Q That's right.
16 DR. GARVER: I think if you had a biomarker for that
17 virus and you had validated it in a lab, then,
18 yes, you could use genomics to identify that
19 virus.
20 Q Okay. Now, in this case where the ocean-tagging
21 studies only predicted 60 percent of the time, is
22 this data that you would find suitable to create a
23 diagnostic test from?
24 DR. GARVER: Well, like I said, you have to identify
25 that signature to ensure that it is definitively
26 just to that virus. For a diagnostic answer, you
27 have ensure specificity and sensitivity. So in
28 other words you want to ensure that you have no
29 false positives, and to do that, you need a
30 specific biomarker for that virus.
31 So if you're able to identify a specific
32 signature for virus A, then, yes, you could use a
33 genomic profile to diagnose that. But typically,
34 if you know what the agent is, you're going to
35 seek the agent, you're going to look for the
36 agent. You're not going to use genomics as a
37 diagnostic. You potentially could, but why would
38 you if you know what virus you're looking for,
39 you're going to look for the virus.
40 Q Okay.
41 DR. MILLER: And I'd like to add to that, and I think
42 I've iterated this a couple of times. The
43 genomics approach that we use is for discovery,
44 and that's its sole purpose. It wasn't that we
45 were going to run microarrays on every fish and
46 predict their survivability. The point was we
47 don't understand, or we didn't understand what was

1 undermining performance in the river. We used
2 genomics to try to understand more about potential
3 mechanisms that may be involved.
4 And in this paper it's very clear that we're
5 not expecting to find a single physiological
6 component that can predict all mortality. It
7 would be completely unrealistic. Fish are hit
8 with all kinds of other things in the river.
9 The important point of this work was that for
10 a segment of the population that was coming back
11 into the river they were so ill-affected that
12 there was an effect, even before they hit the
13 river, on their subsequent survival.
14 Q Now, the genomic signature affects different
15 sockeye stocks differently in freshwater, I
16 understand?
17 DR. MILLER: What we found was that we, in this
18 freshwater one, we actually had more -- we had a
19 larger sample size, we had more fish that were
20 tagged. So we were able to derive a study that
21 contrasted three different stocks, and the reason
22 we were interested in that was that there's a lot
23 of work that shows, you know, that stocks are
24 differentially affected by different kinds of
25 physiological components; disease being one of
26 them, but we didn't actually set out to do disease
27 here. We were interested in if we found something
28 that was predictive of survivorship or premature
29 mortality, how well did -- how predictive was that
30 across different stocks.
31 What you need to understand about the three
32 stocks that we looked at, was that they have
33 difference in their susceptibility to high water
34 temperature stress. And so I think the backdrop
35 to everything that we have here is that the
36 signature alone or the -- even a virus alone, in
37 certain environments, may not have a negative
38 impact. But when you put something that might
39 compromise fish on top of stressful conditions in
40 a river, like high water temperature stress - and
41 my colleagues have done a lot of work on high
42 water temperature stress - you have a greater
43 potential of having a negative impact.
44 And so the stocks that would be most
45 susceptible to high water temperature stress were
46 the Lower Adams, which is a late run stock that's
47 been entering the river early, and the Scotch

1 Creek. Chilko, and there's a publication out of
2 Tony Farrell's lab, is a superfish. It can take
3 high water temperature stress and it can have no
4 ill effects that are measureable.
5 And so the stock that really showed the least
6 proclivity to responding in a negative way to this
7 signature was the Chilko fish, which -- which
8 didn't have the double whammy of carrying the
9 signature and being stressed by high water
10 temperature. And that was one of our hypotheses
11 for why that stock was much less affected. I have
12 others, but we don't need to go into them.
13 Q So to summarize, for the freshwater study the
14 survival of Scotch Creek fish correlated with the
15 genomic signature, and Chilko, and I'm getting
16 from your paper, Late Shuswap, as well, didn't
17 correlate?
18 DR. MILLER: In the freshwater environment there was
19 not a correlation between survivorship of those
20 two stocks.
21 Q So you'd agree, then, that the freshwater tagging
22 study is not consistent?
23 DR. MILLER: You know what's interesting about this
24 signature is that -- is that the signature in the
25 marine environment is suggestive of a very early
26 stage recognition of a pathogen. It's an
27 immunosuppressive signature.
28 The signature that we have in freshwater,
29 although there are enough elements to find a good
30 correlation between those signatures, is something
31 of a change, in that -- in that you move from a
32 very early stage recognition signature to a full-
33 blown apoptotic, which means cell death, and
34 stimulation of inflammatory response. And so it's
35 more likely that it's at that point that if there
36 is disease, that that's when disease is starting
37 to come about.
38 And so one of the things that we hypothesize,
39 and I think we might say something about that in
40 this paper, is that at the point when fish are
41 entering freshwater and swimming through
42 freshwater, we hypothesize that it's possible that
43 if there is a virus, that that virus might be
44 being transmitted at that point. So when we're
45 picking up fish at that stage, you know, there's
46 fish that are already affected, but there may be
47 more fish affected as they migrate.

1 And so if -- the point is that if we sample
2 them as early as in the marine environment, if
3 they already have that signature in the marine
4 environment, they're more doomed. They would have
5 had it for a longer period of time.
6 Q Have you done any follow-up studies on freshwater
7 environments and similar to your *Science* paper in
8 subsequent years?
9 DR. MILLER: we're doing that right now in 2010, and we
10 have a 300-fish study, the same three stocks, so
11 we'll be able to look at this relationship again
12 in those same three stocks. The difference is we
13 tagged all of the fish in the marine environment.
14 So, you know, for -- again bringing this back
15 to practicalities, one of the points in doing this
16 was to provide something that might be useful to
17 managers. Managers want to know if there is
18 predictability on -- on what the effects on salmon
19 returns might be, they would like to know that
20 before they hit the river. They would like to
21 know that in the marine environment. This study
22 was encouraging, that we could identify a
23 signature associated with poor performance in the
24 river before they made it to the river. So that's
25 before they opened the major fisheries in
26 Johnstone Strait and Juan de Fuca Strait.
27 And so we decided this year to focus, or in
28 2010 to focus our efforts on the marine
29 environment, but still looking at mortality in the
30 freshwater environment. Because if we were to
31 develop tools from this, that's where the --
32 that's the point where managers want that ability
33 to predict.
34 Q And do you know when those studies will be
35 published or be available?
36 DR. MILLER: We just ran the microarray study. We
37 actually got some -- and it's a -- the unfortunate
38 thing is it's a new array, it's not the same array
39 that we used. The array that we used here is no
40 longer available, so we're using a different array
41 which has a different complement of genes. But
42 the results I've seen so far are very encouraging
43 that we do have some important signatures
44 associated with survivorship.
45 Q Now, I also understand you did a spawning ground
46 study, as well?
47 DR. MILLER: The spawning ground study was -- it was a

1 bit of an add-on. There was a graduate student in
2 Scott Hinch's group who was looking at factors
3 associated with pre-spawning mortality at the
4 spawning grounds. And so, yes, there was a
5 tagging study and we were able to get her fish and
6 use them in our study, as well. This came quite a
7 bit later than the other studies, and this is what
8 held up publishing this, because we wanted to wait
9 for it to look at that third environment.
10 Q And I understand that 3.7 was the odds ratio for
11 that study, and that as a result they were not
12 statistically significant?
13 DR. MILLER: It was a very -- it really was we were
14 looking to see whether or not it was consistent,
15 but the sample sizes for that study were
16 significantly smaller, and because that's all the
17 fish we could get. So recognizing that we were
18 really on the limits of being able to find
19 something that was truly significant, the trend
20 was still the same.
21 Q So then for the three studies, again, the genomic
22 signature isn't predictive for a diagnostic test
23 for predicting mortality. You'd agree with that?
24 DR. MILLER: I would say that the point, the first and
25 foremost point of this study was to uncover
26 potential mechanisms associated with poor
27 performance in the river, and also to have a
28 better understanding of whether or not salmon were
29 already physically compromised, physiologically
30 compromised before they reached the river. I
31 would say we have absolutely done that.
32 I would say in terms of the predictive nature
33 of this, this is a one-year study, and clearly one
34 needs to do this in more years and with more fish
35 in order to really develop something that's truly
36 predictive. So I wouldn't want to go out tomorrow
37 and say I have a test, you know, to predict
38 mortality in any year in any stock.
39 Q Have you done any analysis on whether or not the
40 differences in gene expression are a result of
41 chance, or not a result of chance?
42 DR. MILLER: I don't know what kind of studies you're
43 imagining. But randomizing samples, are you
44 thinking technical, or I don't -- I don't
45 understand the question.
46 Q Oh, I'm trying to find out the confidence level.
47 DR. MILLER: That there is a signature?

1 Q Right.
2 DR. MILLER: Well, I mean, we've demonstrated this same
3 signature in gill tissue in multiple years. We've
4 demonstrated a highly correlated signature in
5 other -- in other tissues that do not correlate
6 with any kind of technical effects of running
7 microarrays. Those can, I mean, we can get
8 correlations of over .95 between different studies
9 for this signature. So I do think that we have
10 validated that this is something biological as
11 opposed to technical.
12 Q If we could turn to Figure 3 of Exhibit 558. As I
13 see it there is -- maybe if you could explain this
14 figure for the Commissioner.
15 DR. MILLER: Okay. This figure shows biological
16 processes and the biological processes are shown
17 on the left. Pro-virus integration is a
18 biological process. These kinds of biological
19 processes are called gene ontologies, and for
20 every -- for every gene it is involved -- each
21 gene is involved in a number of different
22 biological processes. And so when we do an
23 analysis that is called a functional analysis,
24 we're looking at all of the genes that are present
25 on the array, and what are all of the biological
26 processes or GO terms, as what -- as people call
27 them, that they are involved in. And then we're
28 looking if we have a list of genes that defines a
29 signature, what among those biological processes
30 are statistically over-represented in that list of
31 genes. And so that's what this figure shows are
32 the biological processes that are found
33 statistically associated with this particular
34 signature.
35 So on the bars on the graph, the ones that go
36 to 0 to -3, those are processes that are down-
37 regulated, so that are -- that think of as
38 pathways that are being turned off in fish with
39 the MRS signature, and the ones that go from 0 to
40 3 are pathways or GO terms that turned on in the
41 fish with the signature relating to higher
42 mortality.
43 Q Now, I understand you had some complex results and
44 in seven of the 40 biological processes some were
45 at the same down-regulated and up-regulated?
46 DR. MILLER: That means you really can't describe, you
47 really can't prescribe which direction the pathway

1 goes. That is quite common in microarray studies
2 that, you know, sometimes it's very clear what
3 your directional. But what you have to understand
4 about -- about the technique is there are genes
5 that can be negative effectors and genes that can
6 be positive effectors of a pathway. So you can
7 have a gene that actually when it's turned on,
8 it's turning the pathway off. Right? And then
9 you can have other genes that when it's turned on,
10 it's turning the pathway on. So it is quite
11 complex.
12 So when you get this -- when you get this
13 mixed pattern where it's not really clear that
14 most of the genes are being stimulated, then you
15 have to go and say, okay, what's the effector of
16 each of these genes? What do they do, and is it
17 that you have ones that are being, you know,
18 turned off are actually the repressor. So it can
19 be quite complicated.
20 We didn't go into that detail here and most
21 people don't. Most people simply show which ones
22 are obviously being activated and deactivated, and
23 that's what we've done.
24 Q I understand for the purposes of your *Science*
25 paper the samples were taken from the gills, and
26 that's not the ideal sample, and specifically the
27 ideal sample are heart, kidney or brain. And I
28 understand you've done that subsequently?
29 DR. MILLER: Yes. The reason we have to take samples
30 from a gill when we're doing radio tracking is
31 because it is a non-destructive tissue. You can't
32 take the brain of a fish and have it swim to the
33 spawning ground. So it really is, it really is
34 our only choice. We can use gill, we can use
35 skin, we can use muscle, but you really -- it's
36 absolutely true that you are limited into what, if
37 you're going to combine with radio tracking,
38 you're limited in what kinds of physiological
39 processes you can look for. And we have followed
40 this up using destructive samples from other
41 tissues.
42 Q Okay. So my question is I understand that you
43 were only getting inconsistent results on an
44 individual level where some would have brain
45 tissue that showed the MRS and others would show
46 heart tissue only that had the MRS?
47 DR. MILLER: I don't understand the term "only". But,

1 yes, we do find, and this really was highlighted
2 in our 2005 studies, where we looked at the same
3 fish over three different tissues and showed that
4 the signature, the highly correlated signature was
5 present in each of those, but the prevalence in
6 each of those was really quite different. And the
7 prevalence in that study, I believe was highest in
8 the brain and lowest in the liver.
9 Q And I'm assuming there will be more research on
10 that in the future, that you'll narrow that down
11 and...
12 DR. MILLER: Absolutely. I mean, right now we're doing
13 a lot of work on adults, other than the work that
14 combines the radio tracking with the genomics.
15 But we are doing a lot of work on smolts. So we
16 will have a lot of information about -- most of --
17 we're running smolt studies using multiple tissues
18 where we'll be able to say at an individual level
19 what proportion of individuals carry this
20 signature in one, two and three tissues.
21 I should add that with the virus, the
22 parvovirus that we've identified in tissue that
23 contains this signature, kidney is actually
24 probably the best tissue we could have been using.
25 Q Now, just moving on to the histology samples that
26 Dr. Marty analyzed for yourself.
27 DR. MILLER: Yes.
28 Q I understand that his conclusion was that they --
29 the lesions were related to blunt force trauma.
30 DR. MILLER: You're talking about the brains.
31 Q That's right.
32 DR. MILLER: So we sent in 2009 when we first observed
33 what we thought were abnormalities in the brain,
34 we had histological slides made of those. Those
35 were from -- the slides were made in our Fish
36 Health group. They took one -- they took two
37 slices from the middle of the brain, and made
38 slides into them -- or made them into slides.
39 They took 12 brains total. All of those brains
40 came from the spawning grounds.
41 You know, one of the issues is that when
42 we're doing our genomics, as I said before, we're
43 doing the genomics and we use the whole brain. So
44 and the other thing is that when we're doing --
45 when we're doing the dissections or even the
46 collections, we don't collect histology-grade
47 brains. We collect this -- these samples for

1 doing RNA work, and the kinds of the chemicals one
2 uses for that are different from the kinds of
3 chemicals you would use for histology.
4 So the only reason I'm bringing that up is
5 that those were the only brains that we had that
6 were collected in -- that were either collected in
7 a chemical and never frozen, which you can't
8 freeze if you're going to do histology, or they
9 were collected in histology chemicals. So
10 although we'd seen these what we thought was
11 anomalous in smolts and in other -- in other
12 points along the migration, the only samples we
13 had available to run histology on were spawning
14 ground samples.
15 And so Dr. Marty got 12 brains that we had
16 classified according to whether or not they
17 contained these what we thought again were
18 lesions. And when he read those slides, he
19 concluded that they were likely arising from
20 haemorrhages and they were likely arising from
21 haemorrhages from as a sampling artefact, as an
22 artefact of the handling of the fish.
23 Q I just want to make clear, I mean no criticism by
24 that question at all.
25 DR. MILLER: No, I'm just being clear.
26 Q Yes.
27 DR. MILLER: I'm just trying to be clear.
28 Q Exactly. And I just wanted to clarify that point
29 so we could nail down the brain tumour issue.
30 DR. MILLER: That's fine. Yeah.
31 Q Now, at this point you're not in a position to
32 definitively identify the cause of the MRS as a
33 novel virus.
34 DR. MILLER: The cause of the MRS as it -- are we --
35 okay, yes. We have not definitively established
36 that the parvovirus causes the MRS. That is
37 something that is the topic for our disease
38 challenge work.
39 Q And at this point parvovirus in fish, this will be
40 the first time it's ever been identified, if it is
41 ultimately identified by yourself?
42 DR. MILLER: That is correct. This is the first time a
43 parvovirus has been identified in a fish. They
44 have been identified increasingly in lower
45 vertebrates in the last decade. generally
46 associated with mortality events.
47 Q And other parvoviruses have been identified in

1 humans, dogs and sea lions?
2 DR. MILLER: Oh, and shrimp and insects and ducks and
3 geese, and a variety of other lower vertebrates,
4 as well, and snakes.
5 Q And Dr. Garver, what are your thoughts on whether
6 parvovirus is linked with the MRS?
7 DR. GARVER: I agree with what Kristi says. At this
8 time we don't have the actual link to the fact
9 that it is the cause of the MRS and that's what
10 we're working towards.
11 Q Now, I understand that you have identified a
12 2,214-base pairing sequence?
13 DR. MILLER: That's correct.
14 Q And that's about 50 percent of the parvovirus
15 genome?
16 DR. MILLER: Yes.
17 Q Does a partial signature necessarily mean the full
18 sequence is there, or is it a possibility that it
19 could be chance?
20 DR. MILLER: I don't -- I guess I don't see how it can
21 be chance, given the kinds of data that we're
22 seeing. Chances of exactly what? It's certainly
23 not endogenous in the salmon genome. It's not
24 something that is -- that is there in the DNA of
25 the salmon. So I don't know where you'd pick up a
26 partial viral sequence by chance.
27 Q And at this point have you done any histopathology
28 to determine if the genomic signature or
29 parvovirus is associated with disease?
30 DR. MILLER: That again is something that we're going
31 to concentrate on with the disease challenge work.
32 We have done a little bit of histology, taking
33 some fish that were parvovirus positive from --
34 that were sampled from smolts sampled in the
35 marine environment. The thing to recognize is
36 that when we sample fish in the marine
37 environment, at the time that we're sampling them,
38 we're sampling live fish. We're not sampling at
39 the time of death.
40 And I am not a histologist, but from what I
41 understand of histology, the histology will become
42 a lot stronger and more powerful and easier to
43 detect if you're sampling fish at a later state of
44 -- at the latest state of disease. And most -- a
45 lot of histology that's done in concert with
46 disease, but not all - Gary Marty has a study on
47 herring that looked at wild herring - has

1 concentrated on fish that -- moribund fish, or
2 fish that are sampled close to death.
3 So when he -- he processed these, we only
4 looked at about ten or 12 samples and he didn't
5 see anything that -- that through histopathology
6 was really conclusively suggested that there was a
7 histological feature that would be associated with
8 mortality.
9 Q Now, while I understand you're getting closer to
10 identifying parvovirus as the cause and studies
11 are ongoing, there still are alternative
12 hypotheses or differentials that it could be
13 related to.
14 MR. TAYLOR: I just rise because the way the question's
15 framed doesn't seem to accord with the evidence,
16 and says "getting closer to finding that 'X' is
17 the cause", as I heard you.
18 MS. CALLAN:
19 Q Well, what I meant by the question was studies are
20 starting to -- there's different possibilities
21 still. They're looking at one hypothesis, but at
22 the other time considering alternative hypothesis.
23 DR. MILLER: I would say that's correct. I mean, at
24 the moment we have enough to keep going with the
25 parvovirus and keep going with the research to
26 establish whether or not the parvovirus is (a)
27 associated with the signature, (b) causative of
28 the signature. If we find that it is not, then
29 obviously we have a couple of things to do, one of
30 which is to go back and say, well, okay, what else
31 might be there that we're missing, that might be
32 associated with this signature. And maybe
33 there's, you know, another -- another infective
34 agent that we have missed.
35 But I think we will still continue on with
36 our work on this parvovirus, because we've
37 identified a virus in sockeye salmon that is at a
38 very high prevalence, and at a very high
39 prevalence at the time point when sockeye salmon
40 are entering the marine environment and undergoing
41 some of the highest mortality that they do in
42 their life history. And so I think that in and of
43 itself makes -- warrants further study into this
44 virus, even if in the end it doesn't happen to
45 correlate with the MRS.
46 Q And, Dr. Garver, do you have anything to add?
47 DR. GARVER: No, just to the fact that we're following

1 the scientific methodology and approach. You take
2 one step at a time. You need to confirm route "A"
3 before you can go to "B" a lot of times. So
4 that's the project that we're -- that's the track
5 that we're on right now.
6 Q Now, I understand in your timeline document, and
7 I'm specifically referring to provincial Tab 20,
8 which is the earlier one from May, as opposed to
9 the later one, that you identified a declining
10 prevalence of the signature in the ocean, but
11 could point to a potential impact of the signature
12 or -- and then goes on a little bit to -- or early
13 marine mortality, and then goes on, but cannot
14 discount the possibility that some individuals
15 recovered from the signature.
16 DR. MILLER: That's absolutely correct. What we're
17 doing at this point in addition to doing the
18 challenge work is to start -- starting to
19 accumulate the information about how prevalent is
20 this, and do we see shifts in prevalence and over
21 space and time, or in years where we have strong
22 year class strength and weak year class strength.
23 When you're working with wild fish, looking at
24 shifts in prevalence is one of the indicators that
25 people use to try to pinpoint what factors might
26 be involved in declines.
27 I should point out that there's studies on
28 disease that have taken place in Oregon on wild --
29 on wild chinook and coho salmon from the Columbia
30 system. And one of the things that they found,
31 they look at BKD, and they look at -- they look at
32 various parasites. And I believe Mike Kent was
33 even involved in some of these studies. It's out
34 of Kym Jacobson's lab. And what they have found
35 over ten years, so they've been at this longer
36 than we have, is that -- and they only sample --
37 and they only, I should caveat, they only sample
38 fish in June in the ocean. What they have found
39 over ten years is that they can't -- in years
40 where ocean conditions are poor, they can't find a
41 fish with BKD in the ocean when they go out and
42 sample in June. Now, recognizing that when they
43 go out and sample in June, the fish have been in
44 the ocean for a month and a half or two months, if
45 they go out into the ocean when the conditions are
46 good, and good for growth of smolts, they can find
47 up to 70 percent of the smolts that contain very

1 mild infections with BKD.
2 And they found a very similar result when it
3 came to -- when it came to parasites. They can't
4 find fish that have a heavy parasite load when the
5 ocean conditions are poor. They can find fish
6 with three or more parasites when the ocean
7 conditions are good.
8 And what they have concluded is that fish
9 disease is not tolerated when the ocean conditions
10 are poor. Those fish that carry disease, simply
11 don't survive. What they've missed in their
12 studies, however, is that they don't link it to
13 the freshwater, so they don't really know on an
14 annual basis how many diseased fish might have
15 gone out into that environment. And I would say,
16 you know, that's something that we're interested
17 in, as well.
18 So right now, with the declining prevalence,
19 we're looking for patterns, and the signature in
20 2008 and in 2007 - mind you, small sample size -
21 showed a declining pattern in the prevalence of
22 the signature.
23 We have since now also focused on this
24 parvovirus and we see the same thing. We see when
25 we see the parvovirus that the highest prevalence
26 is in the river. We see a declining prevalence in
27 the early ocean environment. But hints to that
28 decline may vary in different years, so the degree
29 of decline that we observe may not be the same in
30 every year. And that is what I'm focused on, is
31 how much does it decline.
32 But you're absolutely right in that we do
33 need to establish whether or not fish could
34 recover, and/or or whether a decline is always
35 going to be associated with mortality, and we have
36 not established that.
37 The other thing that I would just like to say
38 is that we, with the parvovirus, we have been
39 sampling a broad range of stocks and we've sampled
40 a broad range of stocks in the Fraser River. In
41 last year, in 2008, there were over 400 fish
42 collected in the marine environment in May and
43 June in the ocean, and we looked at the presence
44 of this parvovirus sequence in those fish, and the
45 only stock that we could not find the parvovirus
46 in that we had a sample size of over 15 fish for
47 was Harrison. And we had 51 Harrison fish.

1 Harrison is the one stock in the Fraser River
2 that is increasing in productivity. Why that's
3 important is that we're looking for patterns.
4 Okay? We don't have all of the data to show
5 disease and to show mortality yet. We're working
6 towards this. We are working with wild organisms.
7 But everywhere we turn we see indications that
8 indicate that what we're looking at could have a
9 negative impact at this life history stage.
10 MS. CALLAN: Thank you, those are all my questions.
11 MR. MARTLAND: Mr. Commissioner, next on the list of
12 counsel, I have counsel for the B.C. Salmon
13 Farmers Association at 30 minutes.
14 Indeed, maybe just to clarify the record,
15 then. I think there was a document on screen that
16 may not have been marked. And perhaps I can just,
17 by way of a interjecting question without taking
18 anyone's time, I hope, confirm, Dr. Miller, is
19 that an earlier draft of the timeline document
20 that had been provided and put into evidence as
21 1517, Exhibit 1517?
22 DR. MILLER: I can't tell if it's early till you see
23 the end.
24 MR. MARTLAND: All right. Maybe we can. Is the best
25 way to do that to go to the very end, and perhaps
26 the equivalent of "DD".
27 DR. MILLER: Yes, if it says July, that's the most
28 recent one.
29 MR. MARTLAND: Okay.
30 DR. MILLER: That's the old one, because I see it ends
31 in May.
32 MR. MARTLAND: Thank you. If this might be marked,
33 then, as the next exhibit.
34 THE REGISTRAR: It will be marked as 1522.
35
36 EXHIBIT 1522: Miller, Timeline of Genomic
37 Research relating to the Mortality-related
38 Genomic Signature Hypothesized to be
39 associated with a potentially Novel Virus,
40 May 2011
41
42 MR. BLAIR: Mr. Commissioner, for the record, Alan
43 Blair appearing for the B.C. Salmon Farmers
44 Association. I note the hour. It's three
45 o'clock, and I'm in the Commissioner's hands
46 whether we take a break now or later.
47 THE COMMISSIONER: You can carry on, Mr. Blair.

1 MR. BLAIR: Very well, thank you, then.
2
3 CROSS-EXAMINATION BY MR. BLAIR:
4
5 Q Drs. Garver and Miller, I'll start firstly with
6 you, if I may, Dr. Miller. We've been speaking of
7 course in this Commission about the effect on
8 Fraser River sockeye. But I believe that the
9 studies you've done and the reports that you've
10 been discussing today indicate that you found this
11 signature in a variety of salmon stocks, not only
12 in sockeye; is that correct?
13 DR. MILLER: That is correct. We have observed it in
14 chinook and much less powerfully so in coho.
15 Q And in any of the other species, or have you
16 looked?
17 DR. MILLER: We haven't looked, but we have -- we now
18 have some sample collections of pink and chum, so
19 we will be looking at them.
20 Q And what about the distribution, where were these
21 fish from that you found the signature?
22 DR. MILLER: Most of our work has been about the Fraser
23 River, but some of our coho and chinook have
24 extended to East Coast of Vancouver Island and
25 Burrard Inlet stocks. We have in our chinook
26 salmon work extended as far as the Columbia River
27 system, and we do see this signature in the
28 Columbia in chinook.
29 Q I have a note here, and perhaps you can just
30 confirm whether this is correct or not. But have
31 you also found the signature in some of the rivers
32 to the north? I'm thinking the Skeena, the Nass,
33 Stikine.
34 DR. MILLER: We have not. I believe we might have
35 looked at a fish or two, but we really haven't got
36 -- we haven't looked at a lot of samples to the
37 north. We have some. Dr. Trudel conducts high
38 seas surveys every year, multiple times a year,
39 that go up to southeast Alaska. So we do collect
40 and we run stock ID, so we know where the fish
41 from those collections come from. And so we do
42 have some fish that are from more northerly stocks
43 and we will be running them, but we haven't really
44 done a lot of work on them yet.
45 Q So are you able to say whether you found the
46 signature in any of these northern stocks, or
47 that work is yet to be done?

1 DR. MILLER: I am not able to say that right now.
2 Q And I think earlier in the day we heard reference
3 to Haida Gwaii, that's of course a jurisdiction,
4 and it's also an area that people often refer to
5 in terms of where the stocks migrate past. Have
6 you received information in terms of a signature
7 in the Haida Gwaii area?
8 DR. MILLER: In returning adult salmon, we do see the
9 signature in fish in the Haida Gwaii, yes.
10 Q And what about the Strait of Juan de Fuca?
11 DR. MILLER: Yes, we see the signature there, as well.
12 Q Now, of course everyone's been very curious about
13 your work, and that includes my client, the B.C.
14 Salmon Farmers Association. And is it true to
15 characterize the discussions you've had with the
16 B.C. Salmon Farmers generally, and maybe more
17 specifically with Mary Ellen Walling, the
18 Executive Director of the Salmon Farmers
19 Association, that you've indicated to the
20 association that the data you have to date doesn't
21 point to a strong involvement of salmon net pens
22 in the transmission of the virus to migrating
23 salmon?
24 DR. MILLER: We have no direct data on aquaculture
25 fish. However, the finding that fish are leaving
26 the river with the highest prevalences of this
27 would stand to suggest that a lot of the
28 transmission of this virus - and I'm talking the
29 virus right now, but one could say the signature,
30 as well - because the highest prevalence of the
31 signature is also in freshwater, seems to emanate
32 out of the freshwater environment. That doesn't
33 mean that there couldn't be transfer in a marine
34 environment, but it does mean that we don't have
35 data pointing to that.
36 Q And also in your discussions with the people at
37 the BC Centre for Aquatic Health Sciences,
38 sometimes referred to by its acronym, CAHS, you've
39 also had discussions noting that the signature
40 present in the returning adult salmon migrating
41 through Haida Gwaii, the signature has shown up
42 before they would have encountered the salmon
43 farms closer down, further south?
44 DR. MILLER: That is correct.
45 Q Now, there was a reference just a few moments ago
46 about the Harrison stock, and I think I understand
47 that in the samples you've done of the Harrison

1 stock, you've not found the signature in that
2 stock?
3 DR. MILLER: We've looked at 156 samples now. I only
4 talked about one, what we looked at last year at
5 kidney tissue, but we've also looked at liver
6 tissue and brain tissue, and we've looked at 156
7 different fish, and we haven't found a single
8 positive smolt from the Harrison.
9 Q Now, the Harrison sockeye have some of the
10 shortest residence time in freshwater in the
11 Fraser system?
12 DR. MILLER: Yes, they do.
13 Q And is it true to say that in terms of the
14 relative prevalence rates, your studies have shown
15 the highest -- amongst the highest prevalence
16 rates in those sockeye salmon from the upper
17 reaches of the Fraser, in other words, those with
18 the longest residence time in the freshwater
19 environment?
20 DR. MILLER: In 2010, certainly that did appear to be
21 the trend, that the higher prevalence was in --
22 was in stocks that were further up the river.
23 Q And so are you able to draw any conclusions, or
24 have you drawn any conclusions in terms of the
25 relationship to the relative prevalence and the
26 residence time in the freshwater systems?
27 DR. MILLER: Well, the unfortunate thing is, and maybe
28 this will be easier in chinook where we have more
29 stocks within the Fraser River that have those
30 alternative life histories. I mean, Harrison fish
31 are the only Fraser River stock with a life
32 history that puts them in the river for less than
33 a year. And so that chinook salmon, they, you
34 know, we have ocean type and stream type chinook
35 salmon stocks and we are interested in that
36 question, whether or not that relates to the
37 difference in the life history strategy, or
38 something unique about Harrison.
39 I should say that we did find positives in
40 the Birkenhead system, which Birkenhead fish
41 actually swim by Harrison, by Harrison Lake in
42 order to get to Birkenhead, and we do see
43 positives in Birkenhead.
44 Q And is that an anomaly at present you're not able
45 to explain, or just not sufficient evidence?
46 DR. MILLER: We need -- we need more data to try and
47 understand it. But I think, you know, we're doing

1 a study right now, which is -- which is
2 contrasting Harrison and Chilko in sockeye, and a
3 variety of chinook salmon, stream type and ocean
4 type stocks. And we're not only looking for this
5 signature, we're looking for other physiological
6 factors that may differentiate them. Because just
7 like in Harrison and the other stocks in the
8 Fraser River, in the chinook salmon, the stocks
9 that are in the worst decline tend to be those
10 that have a life history more like the bulk of the
11 sockeye salmon. So the fish that spend less time
12 in freshwater tend to be doing better than those
13 that spend more.
14 Q Now, you made reference to the phrase "lifecycle",
15 and you also referred earlier today to the recent
16 communication, and I believe also communication
17 with the salmon farmers that was not so recent,
18 you've been endeavouring to coordinate the
19 sampling with the assistance of the salmon
20 farmers, and you now understand that fish will be
21 coming from the various companies that make up the
22 B.C. Salmon Farmers Association?
23 DR. MILLER: Yes. That's absolutely correct.
24 Q And I think it was Dr. Garver who spoke about the
25 protocols necessary for doing work, it's your
26 intention and your understanding that the B.C.
27 Salmon Farmers will cooperate and provide a whole
28 series of lifecycle stages of fish from a variety
29 of different farms across the spectrum of the
30 industrial salmon farms. Is that your
31 understanding? I see you looking to Dr. Garver.
32 DR. MILLER: Oh, I thought you were asking him.
33 Q No, no, I was asking you.
34 DR. MILLER: I don't think he knows, because he wasn't
35 involved in those initial discussions.
36 Q All right.
37 DR. MILLER: So I was looking at him, wondering if he
38 was going to answer that.
39 Q Well, he might be, he could try.
40 DR. MILLER: No, that is my understanding. Again, you
41 know, I've really only emailed back and forth with
42 Mary Ellen Walling. I haven't spoken with the
43 different vets. But I am told that that they are
44 on board with providing those samples, yes.
45 Q So within the lifecycle and also from multiple
46 farms.
47 DR. MILLER: And I did make a mistake, I called them

1 the samples from the river, and I meant from the
2 hatcheries, from freshwater and in the marine
3 environment --
4 Q Yes.
5 DR. MILLER: -- previously.
6 Q I wonder if we could just, Mr. Lunn, pull up
7 Exhibit 1521, and go to page 13, please. This
8 document, before he flashes past the front page,
9 is you've told us when this was written, Dr.
10 Miller. I don't have a note of it. Do you
11 recall?
12 DR. MILLER: This was provided to the Pacific Salmon
13 Commission in June of 2010.
14 Q All right. And at the bottom of page 13, please,
15 Mr. Lunn.
16 DR. MILLER: Hopefully I don't have a date problem here
17 again, but...
18 Q Yes, the last sentence, you've written:
19
20 Given the high prevalence before fish leave
21 the river, salmon aquaculture is not likely a
22 main route of transmission to wild salmon.
23
24 We've covered that point already. I just wanted
25 to -- firstly, these are your words, this is your
26 report, correct?
27 DR. MILLER: Yes.
28 Q Nods don't always transcribe quite as well.
29 DR. MILLER: Sorry. Yes, it is.
30 Q Quite all right. Lawyers are usually guilty of
31 that. So this is -- this was your opinion back in
32 June of 2010.
33 DR. MILLER: Yes.
34 Q And it really accords with your current view, as
35 well, as a result of the recent discussions you've
36 had with the salmon farmers, you've repeated this,
37 you've not changed your point of view in this
38 regard, have you?
39 DR. MILLER: Not particularly. It doesn't dismiss the
40 potential of transfer back and forth between wild
41 and aquaculture fish when they're passing salmon
42 farms, but again, I would say that the main time
43 point of transmission appears to be occurring in
44 freshwater.
45 Q And the last comment about not removing that
46 possibility, you say that, but it's purely
47 speculative because to date you --

1 DR. MILLER: Absolutely. We have no information about
2 Atlantic salmon aquaculture fish.
3 Q Even whether they possess the signature.
4 DR. MILLER: Even whether they possess the signature,
5 or the virus. That is what we're hoping to gain
6 by working with the industry.
7 MR. BLAIR: Thank you. Mr. Commissioner, did you want
8 to take a short break now?
9 THE COMMISSIONER: Yes, thank you.
10 MR. BLAIR: Thank you.
11 THE REGISTRAR: The hearing will now recess for 15
12 minutes.
13
14 (PROCEEDINGS ADJOURNED FOR AFTERNOON RECESS)
15 (PROCEEDINGS RECONVENED)
16
17 THE REGISTRAR: Order. The hearing is now resumed.
18 MR. BLAIR: Thank you, Mr. Commissioner.
19
20 CROSS-EXAMINATION BY MR. BLAIR, continuing:
21
22 Q Dr. Garver, these questions are for you, and they
23 relate to IHN. My question, in a general sense,
24 is there any evidence that the prevalence of IHN
25 stocks in B.C. sockeye salmon have changed since
26 the 1990s?
27 DR. GARVER: So a predecessor of mine, Garth Traxler,
28 began a surveillance program for IHNV in various
29 sockeye salmon stocks, and so we have -- it's
30 actually one of the few diseases or pathogens that
31 we have a very long-term monitoring program for,
32 and he started this back in 1986. And what we
33 found is that the prevalence values vary
34 considerably from year to year and between stocks,
35 and since that monitoring period there were a few
36 outbreaks in salmon farms. And when we compare
37 those times during the outbreaks to the stocks
38 that we are looking at for IHN prevalence, it
39 didn't appear to change the prevalence in the wild
40 stocks. In other words, it wasn't a driving
41 factor for the occurrence IHNV in the wild stocks.
42 Q And in that work, sir, did you find whether there
43 was any correlation in the IHNV prevalence as
44 between adults and its occurrence in fry?
45 DR. GARVER: No. And that was the big motivation
46 behind beginning the monitoring program, is to
47 establish something where we could predict the

1 occurrence of IHN disease in our wild stocks, and
2 so Garth Traxler had looked at the adult -- the
3 prevalence in adults, and in the subsequent year
4 the fry from those adults, looked at the
5 prevalence in there. And when we run the
6 correlations, there is no correlations between the
7 prevalence in adults and those that occur in its
8 offspring the following year.
9 Q And I think another part of your work in your
10 summary could be summarized as this; that is, that
11 your work suggests -- has suggested that IHNV is
12 not a major contributor to the long-term decline
13 of these two stocks, and by the two I'm referring
14 to the Weaver Creek and Nadina River?
15 DR. GARVER: That's correct. There has been episodic
16 events which have caused catastrophic mortality,
17 particularly in the Weaver Creek. Garth Traxler
18 documented this in, I believe it was, a 1987
19 publication that the outbreak occurred in 1986,
20 and it killed that Weaver Creek, it killed about
21 50 percent of the fry, so there was a dramatic
22 impact at that, but it was epizootic in that it
23 wasn't reoccurring every year. And so from what
24 we have to date is dated to suggest that, yeah, if
25 we're looking at a long-term trend where IHN or
26 reduced productivity in the Fraser stocks, the
27 sole factor wouldn't be IHN.
28 Q So noting the outbreaks as you've just done, it is
29 correct to characterize that IHNV was not a major
30 contributor to the long-term decline of the
31 stocks, but you had spikes when it went through
32 those two systems?
33 DR. GARVER: There are spikes, that's correct. And the
34 problem is, it's very difficult with diseases.
35 There could be compounding factors. So if you
36 have other diseases or other environmental factors
37 that increases the susceptibility to that disease,
38 a lot of those we don't have determined and IHN
39 would fall into one of those categories we don't
40 know all the predisposing factors to disease.
41 MR. BLAIR: Thank you, Dr. Garver. Thank you, Dr.
42 Miller. Thank you, Mr. Commissioner.
43 MR. MARTLAND: Mr. Commissioner, counsel for the
44 Aquaculture Coalition is next, with 65 minutes.
45 That'll run us till 4:00 and then continue
46 tomorrow, I expect.
47 MR. McDADE: Dr. Miller, Dr. Garver, my name is Gregory

1 McDade, and I am counsel for Dr. Alex Morton and
2 for the Aquaculture Coalition.
3
4 CROSS-EXAMINATION BY MR. McDADE:
5
6 Q Just in starting, Dr. Miller, my client has
7 instructed me to say that we want to thank you for
8 your courage and for the fascinating work that
9 you've done on these studies. It's obviously very
10 important.
11 It's a bit of a detective story, as I hear
12 it, unwinding some of this, and clearly we're in
13 the middle of a scientific process. So as I
14 understand it, you weren't looking for a disease
15 or a virus when you started this work, you were
16 looking for the explanation for early entry?
17 DR. MILLER: Early entry and for survivorship in the
18 river, yes.
19 Q And what you found is what is likely but not
20 proven to scientific certainty yet, some sort of
21 new virus?
22 DR. MILLER: That is correct. We have identified a
23 novel virus, meaning it hasn't been described
24 before. The sequence of a novel virus in salmon
25 that contained the signature that we identified in
26 the *Science* paper.
27 Q And your current leading, if I can put it, suspect
28 in this matter is the parvovirus?
29 DR. MILLER: At the moment, that is our candidate
30 virus.
31 Q And you haven't confirmed it's parvovirus, that's
32 what you're working on?
33 DR. MILLER: If the question is, we haven't confirmed
34 it's parvovirus that causes the MRS --
35 Q Yes.
36 DR. MILLER: -- that is correct. That is what we hope
37 the disease challenge work will do.
38 Q And for a couple of years, or certainly in a lot
39 of your early material, your leading suspect was
40 salmon leukemia virus?
41 DR. MILLER: Yes, it was.
42 Q And as I understand it, you haven't ruled out
43 salmon leukemia virus, at this point?
44 DR. MILLER: No, I have not. It has to be clear that
45 the salmon leukemia virus, itself, has never been
46 isolated. There's no sequence information for it.
47 So there is a postulated virus associated with

1 plasmacytoid leukemia, and the work,
2 unfortunately, of the investigators of
3 plasmacytoid leukemia never identified a specific
4 viral agent associated with that disease. It is
5 still possible that this parvovirus could somehow
6 relate to that.
7 Q Right. Because SLV was never actually -- what was
8 your term?
9 DR. MILLER: It's never been isolated in sequence, so
10 there is no cell culture of it, there is no
11 sequence of a virus, there's no confirmation that
12 a virus actually existed, direct confirmation.
13 Q And similarly, you haven't successfully cultured
14 parvovirus?
15 DR. MILLER: We have had equally difficult and lack of
16 success in terms of culturing the parvovirus yes.
17 Q So we're really in the same place with those two
18 viruses, at this point?
19 DR. MILLER: At this point, we certainly don't have
20 evidence that it's not that, but we don't have any
21 evidence that it is, directly.
22 Q And the symptoms, what led you to first suspect
23 salmon leukemia virus is that the symptoms you
24 were finding were quite a bit similar?
25 DR. MILLER: Yes. You know, some of the symptoms that
26 I talk about are things that I hear from the
27 field. People who are on the ground sampling
28 sockeye salmon, David Patterson is my collaborator
29 that's on the ground, and his team, and oftentimes
30 they have noted, you know, associated with these
31 mortalities in the river, you know, the fish look
32 really healthy, they look really good externally,
33 sometimes they have pale gills, sometimes they see
34 to have bleeding disorders, but not looking
35 through histology but just simply looking at the
36 condition of the fish from an external standpoint,
37 they look really good and healthy, and those are
38 sometimes the kinds of things that people would
39 say when fish were, at least that I had heard,
40 when fish were dying of marine anemia, that they
41 were fish that actually looked good, externally,
42 not necessarily through histology, that had pale
43 gills and they were simply dying.
44 And so I thought that that was an interesting
45 parallel. And the other interesting parallel was
46 that, you know, the pale gills is an indicator of
47 anemia and the marine anemia, or plasmacytoid

1 leukemia, you know, is an anemia-related disease.
2 We've seen anemia-like symptoms in sockeye salmon
3 as well.
4 Q And really, the primary similarity is
5 immunosuppression, if I've pronounced that
6 correctly. They're both diseases of
7 immunosuppression.
8 DR. MILLER: A large number of viruses, and Kyle can
9 speak to this probably better than I can, but, I
10 mean, many viruses can induce immunosuppression
11 but, you know, yes, that is potentially another
12 comment feature.
13 Q And I understand that the suspect salmon leukemia
14 virus was a retro virus, which -- and the
15 parvovirus is a DNA-based virus?
16 DR. MILLER: As far as I understand it, and you had the
17 two experts sitting here the last two days, and
18 you will have another expert, Sonja Saksida from
19 CAHS, here in another week, week and a half, who
20 will be testifying. She did a masters degree on
21 plasmacytoid leukemia as well. And as I
22 understand it, the evidence that it was a retro
23 virus and not some other kind of virus was two-
24 fold. One, that they had positive RT assays; and,
25 two, that they thought that they observed tumours
26 behind the eyes of the fish that carry
27 plasmacytoid leukemia. Now, I'm sure you were
28 listening when Mike Kent was testifying in the
29 last couple of days, and he seems to have
30 backtracked on whether or not those lesions behind
31 the eyes were, in fact, tumorous, or whether they
32 could have been inflammatory cells, and I was
33 quite -- that was the first time I'd ever heard
34 that mentioned.
35 So I guess I'm not -- he's not, now -- he
36 doesn't appear to be strongly convinced that it is
37 a retro virus anymore, and so I'm a little bit
38 less convinced that it has to be a retro virus
39 associated with that and not something -- some
40 other kind of virus.
41 Q So is it fair to say that at this point you
42 haven't ruled out a retro virus or a DNA virus, it
43 could be either?
44 DR. MILLER: We, in sequencing about 250,000 different
45 reads of RNA, we did not uncover any retro viral
46 sequences that were not already endogenous in the
47 salmon genome. But that's not, you know, that's

1 the most intensive sequencing one can do. When
2 heart and skeletal muscle inflammatory disease,
3 when they identified a real virus in association
4 with that, out of a couple hundred thousand reads,
5 they only got one 240-base sequence one time out
6 of that, that turned out to be important and they
7 went back and they did another 500,000 reads to
8 actually get more of the virus. So it's not
9 impossible that there could be other viruses, you
10 know, contained in fish that carry that signature,
11 but right now my feeling is we need to follow
12 through the parvovirus, see whether that could be
13 causative. If it's not, we'll go back and see
14 what else there might be.
15 Q And HSMI, or heart and skeletal muscular, is
16 currently a disease causing significant problems
17 in Norway's fish farms?
18 DR. MILLER: Yes, it is, and it's a disease that has
19 been under study for over a decade and caused a
20 lot of problems for over a decade, and it is only
21 -- and they have been trying to isolate and trying
22 to identify a pathogen associated with it, and
23 they finally came up with a sequence. There's
24 some, still, question as to whether this
25 particular virus is absolutely causative as well.
26 This stuff takes time. But it's only because they
27 used a, really, a genomics approach that they were
28 able to obtain a sequence, finally, after 10 years
29 of studying this.
30 Q So is it possible it could take us a number of
31 years to actually nail this virus down?
32 DR. MILLER: I'm sure hoping not. And, you know, we've
33 cut a lot of corners and I think we've come really
34 far and really fast, but there are some
35 experimental studies that have to be done before
36 we can move too far forward.
37 Q Dr. Garver, is it possible it could take a year or
38 longer to identify this virus, if ever?
39 DR. GARVER: Have you had a science class, because that
40 is science. That is pretty much the definition of
41 science. It will take a considerable amount of
42 time, yes.
43 Q Well, it's been a considerable amount of time
44 since I've had a science class.
45 DR. MILLER: Well, I should just mention, we do have a
46 candidate virus, so if you're saying, "Identifying
47 a virus," we have identified a candidate virus at

1 this time.
2 Q So it's possible that, as I understood your
3 earlier answers, it's also possible that the
4 disease that was being identified, or the virus
5 that was being researched by Dr. Kent back in the
6 nineties might, in fact, have been parvovirus?
7 DR. MILLER: That is definitely possible. The
8 difficulty with trying to relate that disease or
9 that syndrome with the parvovirus is that there
10 don't appear to be tissue samples of fish that
11 carry marine anemia available to compare to the
12 samples that we have. And because there is no one
13 studying that particular syndrome or disease -
14 usually they're called a syndrome unless you have
15 an etiological agent, and then they can be called
16 a disease; I think we learned that in the last
17 couple days - but, you know, it makes it
18 difficult. And I guess if I -- if we can't find
19 someone who's actually studying that and
20 diagnosing marine anemia, it will be very
21 difficult to determine whether or not they are the
22 same thing. Perhaps with histology, if we can do
23 the challenge work and find disease and mortality,
24 perhaps one can look at the histological
25 signatures from the parvovirus and determine if
26 they're anything like what's been observed in
27 marine anemia. That, at the moment, is the only
28 sort of indirect way we've got.
29 Q Okay. So whether this is parvovirus or SLV --
30 well, let me ask it this way: If this is
31 parvovirus, it's never been seen in fish in B.C.
32 prior to this time?
33 DR. MILLER: We did not know if its existence prior to
34 this.
35 Q In fact, I think you're probably on the cutting
36 edge here. It's really the first time it's been
37 identified in fish?
38 DR. MILLER: Parvovirus, yes, it has never been
39 identified in fish.
40 Q So when you get to the point, if you do, of
41 sequencing this, it will be a new virus?
42 DR. MILLER: When we have the full sequence and -- yes.
43 Q So you'll get to give it a name, I suppose? If
44 it's like astronomy, it gets to be called Miller
45 Virus?
46 DR. MILLER: It will get a name when we have a full
47 sequence.

1 Q All right. Because parvovirus is just a generic
2 type of virus, right? It'll be called
3 something --
4 DR. MILLER: It'll have something to do with salmon,
5 probably.
6 Q Right. All right. So whatever its name, whether
7 we call it Miller Virus or something else, it is
8 quite -- what we do know, from your work in
9 science and the last four years of research, is
10 what we do know is that it is associated with a
11 whole early entry phenomenon and the en route
12 mortality?
13 DR. MILLER: There is an association in the 2006 study
14 of the MRS signature with more rapid entry into
15 the river and actually faster migration to the
16 spawning grounds. That study needs to be repeated
17 in other years to ensure that that signature is
18 related to rapid entry into the river in other
19 years, and that's something that we will have from
20 our 2010 data. We have not shown that the
21 parvovirus, itself, is associated with that but we
22 certainly have the samples to do that.
23 MR. McDADE: Mr. Lunn, if I might just put two or three
24 documents up on the screen. They're all related,
25 I think. Let's start with Exhibit 1516, which we
26 looked at earlier today. Now, this document has
27 been identified, and I understand the comments in
28 it were Dr. Garver's, so this is a draft of a
29 document that was later finalized. Can we have
30 Commission document 21 up on the screen.
31 MR. TAYLOR: Just on 1516, I'm not sure if it's ever
32 been finalized or if there's evidence of that.
33 MR. McDADE: Well, that's what I'm about to ask about,
34 I think.
35 MR. TAYLOR: Well, you just started by saying it was
36 later finalized.
37 MR. McDADE:
38 Q Well, I think this is the final version, is it
39 not, Dr. Miller? This is a version dated October
40 7th, 2009. It seems to be a very close
41 correlation with the document we just looked at.
42 I think this is the latest version that I've seen,
43 but I stand to be corrected.
44 DR. MILLER: This was not the final version of a
45 briefing note, if that's what you're asking.
46 Q All right. In any event, this document was
47 prepared by you on October 7th, 2009?

1 DR. MILLER: It was. It was prepared in conjunction
2 with the talk that I gave, the intradepartmental
3 talk that I gave associated with the same title.
4 MR. McDADE: Mr. Lunn, could we put up DFO 59898.
5 That's one of the later documents that have --
6 were produced this week by the Conservation
7 Coalition.
8 MR. LUNN: 598, I think it's a six-digit code. There's
9 a digit missing.
10 MR. McDADE: Sorry, I'll get it for you. 598981.
11 MR. LUNN: There are three files associated with that.
12 I'll bring up the first one to start.
13 MR. McDADE: Yes, that's the one I'm looking for.
14 Q That's also prepared by you, Dr. Miller?
15 DR. MILLER: Yes, that looks to be a slightly earlier
16 version.
17 MR. McDADE: So could we have those two versions marked
18 as exhibits.
19 THE REGISTRAR: Tab 21 will be marked as 1523. DFO
20 598981 will be marked as 1524.
21
22 EXHIBIT 1523: Epidemic of a Novel, Cancer-
23 causing Viral Disease may be Associated with
24 Wild Salmon Declines in BC, by Kristi Miller,
25 dated October 7, 2009
26
27 EXHIBIT 1524: Epidemic of a Novel, Cancer-
28 causing Viral Disease may be Associated with
29 Wild Salmon Declines in BC, by Kristi Miller,
30 dated September 27, 2009
31
32 MR. McDADE: Let's just stick with that particular
33 document for a few minutes.
34 Q So in the first -- in the bullet in the middle of
35 the page, the first open bullet, you note that the
36 salmon starting from 300 kilometres seaward had a
37 16 times lower probability of arriving to spawning
38 grounds in terms of the healthy signature. And in
39 the second bullet, that there is -- it may be
40 associated with losses of up to 90 percent, if you
41 count river entry timing losses.
42 Have you made a calculation of how many fish
43 that might actually involve in the -- we're
44 talking about many, many millions of fish, aren't
45 we?
46 DR. MILLER: Yes. This was based on the prevalence of
47 fish containing the signature and I'm trying to --

1 it's the second bullet you're talking about,
2 right?
3 Q Yes, thank you.
4 DR. MILLER: Oh, yeah, well, and it's also to the
5 additional physiological information, so Scott
6 Hinch and his group have also found physiological
7 indicators associated with advance entry timing
8 and losses in the river, so it was including sort
9 of his estimates as well.
10 Q And can we go to document 15 -- Exhibit 1512. And
11 if we could scroll down to the final bullet there.
12 We looked at this document this morning as well.
13 I see there that you've done a calculation saying
14 if the decreases were really from the causes of
15 mortality, in 2008 there may have been as many as
16 27 million salmon --
17 DR. MILLER: In order to see the decrease in prevalence
18 that we observed, if that decrease in prevalence
19 were to be due to mortality, and that was
20 something that still needs to be demonstrated,
21 that that were how many fish basically that were
22 missing that we didn't see in our second -- in the
23 second sample period.
24 Q And can we go to Exhibit 1513 and go to page 6.
25 We also looked at this, this morning. I just want
26 to try to understand this. And this is a
27 comparison between 2007 and 2008. So in 2007, you
28 found a much heavier prevalence of the MRS in the
29 smolts than you did in the 2008 smolts.
30 DR. MILLER: That's correct. It was a small sample
31 size, because that's all that was available to us,
32 but most of the fish that we sampled in the ocean
33 at the end of June contained this signature in
34 2007, whereas it was less than 40 percent in 2008.
35 We have actually, since, amplified parvovirus out
36 of these same fish and we see the same phenomena.
37 Q The same phenomena was --
38 DR. MILLER: We see a much higher prevalence in 2007
39 than we do in 2008.
40 Q And if, in fact, the mortality is related as we
41 just discussed, that would seem to indicate to me
42 that the impacts in the 2007 smolts or the 2009
43 fish, would be much heavier than that of the 2008
44 smolts, 2010 fish?
45 DR. MILLER: Yes, potentially.
46 Q So we could be talking about many, many millions
47 of fish here?

1 DR. MILLER: I did a calculation somewhere in one of
2 these talks, but yes, we're talking in the order
3 of, I can't remember what it was, three or four
4 times more fish, in the least, between those
5 different years. We're talking millions of fish,
6 yes.
7 Q And so is it fair to suggest that this particular
8 MRS, if it turned out to be the virus and if it
9 turns out to have the mortality that you've
10 speculated about, really could be a very, very
11 significant explanation for the 2009 decline?
12 DR. MILLER: If we can demonstrate that this virus
13 causes disease and has -- and mortality of fish in
14 the early marine environment under certain
15 circumstances, it doesn't necessarily have to be
16 every year, I certainly expect that the role of
17 the environment will be a strong one, but if we
18 demonstrate that when fish are entering the ocean
19 and they become stressed in the ocean and they
20 carry a high load of this virus, that we see
21 significantly enhanced mortality, they're
22 certainly given the prevalence rates of fish that
23 we see in certain years with this parvovirus there
24 is certainly the potential that this virus could
25 have a major impact on salmon declines.
26 Q And if, in fact, that's the case, using the
27 terminology that we heard yesterday, this, in
28 fact, may be the smoking gun for the 2009
29 declines?
30 DR. MILLER: It could be the smoking gun.
31 Q And we have heard you, I think, say, although this
32 matter is not proven, yet, to be a virus that
33 causes disease, you're prepared to say that's your
34 strong speculation that, in fact, that will be
35 proven?
36 DR. MILLER: I have some level of confidence that we
37 will find disease with this virus, but we do have
38 to do the work.
39 Q Now, if I could go back to 1524, and if I could go
40 to page 3 of that document, and if I just look at
41 the last bullet on the page, which is, I think,
42 the end of the document -- oh no, sorry, the end
43 of that section:
44
45 There are several elements of the history and
46 timing of descriptions of PL/SLV that
47 potentially implicate this virus in the

1 large-scale declines of coho and Chinook
2 salmon in BC, and may be suggestive of a role
3 in hatcheries and aquaculture in this
4 decline.
5
6 You wrote that at the time, didn't you?
7 DR. MILLER: I think I should be clear. I was a
8 reviewing a literature that mostly came from Mike
9 Kent and Bill Eaton and others who had done this
10 -- who studied this disease. I wouldn't -- I'm
11 not an expert on plasmacytoid leukemia, but in my
12 purviewing, and I think you've seen the document
13 that I made when I was originally interested in
14 this disease, looking at the timing of various
15 events and looking at the timing of when this was
16 discovered, et cetera, it was my view, at the
17 time, that it was a very interesting disease and
18 it was largely overlooked, and I was interested in
19 whether or not, (a) it could be related to what we
20 were observing in sockeye, and if it was related
21 to what we were observing in sockeye, whether or
22 not it could be a factor in declines of multiple
23 species.
24 Q So could I turn over the page. And you prepared a
25 chart on the next page.
26 DR. MILLER: That's the one I'm talking about.
27 Q Yes. And when you went -- when you were speaking
28 at this time and to the PSC, I've seen on a number
29 of documents that you refer to it as the timing
30 issues. This is one of the arguments at the time
31 you considered in favour of the SLV hypothesis is
32 the correlations in timing between these various
33 matters happening at the same time, isn't it?
34 DR. MILLER: Yeah, the one thing that, given what we
35 know, now, that would need to be removed from
36 this, however, is that we didn't have ocular
37 tumours, and so all references to that, since we
38 saw haemorrhaging in the ocular lobe as opposed to
39 tumours, that that data would not relate, or would
40 not be validated at this point, or would not be
41 accurate.
42 Q All right. That seems quite reasonable. But the
43 key issue about the timing here, as I understand
44 it, is that the connection that was present in
45 your mind then, and is still in your mind today,
46 with early entry, that's a behaviour that goes
47 back to the early nineties?

1 DR. MILLER: Yes. 1996, really. The early entry
2 behaviour in sockeye salmon started in 1996.
3 Q Right. And so that would have been the generation
4 of the brood stock from 1992?
5 DR. MILLER: That's correct.
6 Q And the declines in productivity that we've seen
7 in the sockeye salmon that is behind this
8 Commission's mandate really dates back to about
9 1992 as well, doesn't it?
10 DR. MILLER: In the focus on sockeye salmon and early
11 entry and for --
12 Q The decline --
13 DR. MILLER: The decline --
14 Q The decline of productivity.
15 DR. MILLER: I think it goes about that far. Now, one
16 thing I would also like to correct here, is that -
17 and Mike Kent is the one that corrected this -
18 that they actually did not observe positive
19 sockeye salmon in 1991 in their surveys. That was
20 unclear to me; I thought that they had.
21 Q Because they never looked for it; is that right?
22 DR. MILLER: They did a very cursory look.
23 Q But there's no question that marine anemia or
24 plasmacytoid leukemia, or whatever that disease
25 was, if it was parvovirus at the time, it was
26 killing huge amounts of Chinook fish in fish farms
27 from 1988 to 1991; that was an important fact to
28 you at the time, wasn't it?
29 DR. MILLER: That was of some import to me, but I'm not
30 the one who observed that, so I'm probably not the
31 one who should report on it. But yes, that it had
32 been killing fish, Chinook salmon, during those
33 periods of time, yes, it was something that I
34 thought was important.
35 Q Now, today I heard you say that you'd tend to
36 suggest that aquaculture might not be directly
37 implicated because of the fact that the smolts
38 coming out of the river have this MRS. And I can
39 see the logic behind that. But that doesn't
40 answer the question of where this disease came
41 from in the first place, does it?
42 DR. MILLER: It absolutely doesn't, no.
43 Q And it's quite possible that the -- because you
44 find the adults who have come past the fish farms,
45 or sorry, let's just say the adults coming back to
46 the river show this MRS in a group to a great deal
47 and they're the parents of the smolts, right?

1 DR. MILLER: That's correct. They show the signature
2 regardless of which route they take around
3 Vancouver Island, but yes, they show the signature
4 coming back.
5 Q So that suggests two possibilities to me. One, is
6 the possibility you refer to in this document,
7 which is the disease is vertically transmitted;
8 that is, it's transmitted from the adult fish,
9 through the eggs to the young fish. That's a
10 possibility, isn't it?
11 DR. MILLER: It certainly is not unusual for
12 parvoviruses to be transmitted vertically.
13 However, there was a -- it was an interesting
14 review, I think, that the B.C. Salmon Farmers
15 Association put in by Dr. Lewis, who's a
16 virologist, who suggested that he felt that the
17 probability for vertical transmission was low,
18 because in other species where vertical
19 transmission with parvoviruses was a common route
20 of transmission, you saw loss of the fetus, and he
21 concluded that you would have losses of eggs.
22 Kyle could really respond to this better than I
23 could. We have discussed this. I would say we
24 really don't have any data on this, and it would
25 be pure speculation.
26 Q It is pure speculation. It could be vertically
27 transmitted; it may not be. But that would be one
28 mechanism which would explain why the adults had
29 it and the babies had it?
30 DR. MILLER: Yes, and that is something that we are
31 looking at, earlier life history stages, to find
32 out how early we can identify this parvovirus out
33 of fry.
34 Q And right now the earliest you've identified is in
35 smolts; isn't that right?
36 DR. MILLER: In terms of the signature, the earliest
37 we've identified it is in November before a fish
38 is going to smolt, in their natal rearing areas.
39 So before they leave their natal lakes.
40 Q So that would tend to suggest it's vertically
41 transmitted, wouldn't it?
42 DR. MILLER: It doesn't, necessarily. It can still be
43 horizontally transmitted in the natal lakes.
44 Q From adults?
45 DR. MILLER: Want to jump in, Kyle?
46 Q Yes, go ahead, Dr. Garver.
47 DR. GARVER: I'll just step back here a little bit. As

1 a scientist, I'm really concerned with all the
2 speculation that's going on here. We have a
3 parvovirus sequence. We don't have it linked to a
4 disease. We don't have it linked to mortality.
5 We don't know how it's transmitted. We don't know
6 if it causes disease. We don't have any pathology
7 associated with it. So if we're sitting around
8 discussing scientifically hypothesis, this is
9 fine, but if we're actually trying to get to some
10 answers, it's pure speculation.
11 DR. MILLER: Yes.
12 DR. GARVER: Now, in addition to the other questions
13 that are being asked, yes, there could be multiple
14 reservoirs. Just because we're finding it in
15 salmonids doesn't mean it's not in other fin fish
16 that reside in a lake. So yes, it could
17 potentially be in other species in a lake and
18 could, therefore, be transmitted horizontally.
19 But again, this is pure speculation since we don't
20 even know if it's transmitted, nor do we know if
21 it's infectious.
22 Q All right. Well, I apologize, Dr. Garver, if
23 we're not yet meeting the scientific standards
24 that you have for proof, but it's equally pure
25 speculation that it's not coming from aquaculture,
26 then, isn't it?
27 DR. GARVER: We don't know.
28 Q That's right.
29 DR. GARVER: We don't know where it is --
30 Q No.
31 DR. GARVER: -- and what species it's in. Right now,
32 we don't even know if it's a true virus, other
33 than the fact that we have a sequence.
34 Q Dr. Miller, it must have caused great
35 consternation in the DFO when you put that
36 paragraph in connecting it to aquaculture, in
37 2009, didn't it? You got some blowback on that,
38 didn't you?
39 DR. MILLER: What paragraph are you talking -- I'm not
40 sure --
41 Q Can we go back to Exhibit 1524, then. Just back
42 to that page, just the previous page. That last
43 paragraph there. The first sentence.
44 DR. MILLER: I would say there was concern, but I don't
45 think there was a large pushback.
46 Q Well, if we cam go to 1523, which is -- could we
47 go to the same place in that document, just above

1 number 4, which would be page 3. Now, what I see
2 here is that particular -- when I compare these
3 two documents -- Mr. Lunn, can we put this up,
4 both documents up on the screen at the same place?
5 So that should be enough. What we have there is
6 document one, on September 27th, we have the same
7 five bullets and then a paragraph, and in document
8 two we have the same five bullets and no
9 paragraph. It seems to have miraculously
10 disappeared. Was that because of pressure you
11 received inside the Department?
12 DR. MILLER: I think there was some concern over the
13 speculative nature of that comment in the first
14 one. I honestly don't remember the dialogue that
15 occurred associated with that but I think that
16 many felt that to be highly speculative and not
17 really well supported.
18 MR. McDADE: This would be an appropriate time to
19 break, Mr. Commissioner.
20 MR. MARTLAND: Mr. Commissioner, with respect to our
21 timing, I've been canvassing and continually
22 looking at our schedule. I'd suggest that we
23 convene at the regular time of 10:00 a.m.
24 tomorrow, please. Thank you.
25 THE REGISTRAR: The hearing is now adjourned for the
26 day and will resume at ten o'clock tomorrow
27 morning.
28
29 (PROCEEDINGS ADJOURNED TO AUGUST 25, 2011, AT
30 10:00 A.M.)
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1 I HEREBY CERTIFY the foregoing to be a
2 true and accurate transcript of the
3 evidence recorded on a sound recording
4 apparatus, transcribed to the best of my
5 skill and ability, and in accordance
6 with applicable standards.
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9 ___________________________________
10 Irene Lim
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13 I HEREBY CERTIFY the foregoing to be a
14 true and accurate transcript of the
15 evidence recorded on a sound recording
16 apparatus, transcribed to the best of my
17 skill and ability, and in accordance
18 with applicable standards.
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21 ___________________________________
22 Karen Acaster
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34 Pat Neumann
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42 with applicable standards.
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45 ___________________________________
46 Karen Hefferland
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