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

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

Public Hearings

Audience publique

Commissioner

L'Honorable juge /
The Honourable Justice
Bruce Cohen

Commissaire

Held at:

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Wednesday, July 6, 2011

Tenue à :

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

le mercredi 6 juillet 2011

Errata for the Transcript of Hearings on July 6, 2011

Page	Line	Error	Correction
vi		Exhibit 1292 reads BC Post Study, PNAS	BC POST Study, PNAS
43	26	209	2009
46	16	post	POST
16	4	larvation	larvacean

Suite 2800, PO Box 11530, 650 West Georgia Street, Vancouver, BC V6B 4N7
Tel: 604 658 3600 Toll-free Tel: 1 877 658 2808
Fax: 604 658 3644 Toll-free Fax: 1 877 658 2809
www.cohencommission.ca

APPEARANCES / COMPARUTIONS

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

APPEARANCES / COMPARUTIONS, cont'd.

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

APPEARANCES / COMPARUTIONS, cont'd.

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

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Vancouver, B.C./Vancouver
(C.-B.)
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THE REGISTRAR: The hearing is now resumed.
THE COMMISSIONER: Good morning, Ms. Baker.
MS. BAKER: Good morning. So today, Mr. Commissioner, we have -- I'm Wendy Baker for the Commission and Maia Tsurumi. We have two new counsel in the room as well, Katrina Pacey for Area D and B, and behind me is Heidi Hughes for the Province.
Today we're dealing with marine ecology in our first three days of our marine theme. We have with us today three doctors. We have Dr. Beamish, Dr. Welch and Dr. McKinnell, who will all be testifying this morning. So Dr. Welch has already been sworn in these proceedings, but Dr. Beamish and Dr. McKinnell need to be sworn.
THE COMMISSIONER: You'll need to turn your microphones on, gentlemen, if you could. Just press the button. Thank you very much. Thank you.

DAVID WELCH, recalled.

STEWART McKINNELL, affirmed.

RICHARD BEAMISH, affirmed.

THE REGISTRAR: State your name, please.
DR. BEAMISH: Richard Beamish.
DR. McKINNELL: Stewart McKinnell.
DR. WELCH: David Welch.
THE REGISTRAR: Thank you very much.
MS. BAKER: Thank you. Mr. Commissioner, I'm going to have all three of these gentlemen qualified as experts and I'll do that first with all three, and then I'll begin my questions with Dr. McKinnell.

EXAMINATION IN CHIEF ON QUALIFICATIONS BY MS. BAKER:

Q So starting in that order with Dr. McKinnell, first of all, your c.v. is in Tab 7 of the Commission's list of documents. I'll just get you to identify that's your c.v.?
DR. McKINNELL: That's certainly the first page.
Q Okay. And we'll take you through a few pages in that c.v. All right, so we can identify that?

DR. McKINNELL: Yes.
MS. BAKER: Thanks. I'll have that marked, please.
THE REGISTRAR: The next exhibit is 1284.

EXHIBIT 1284: *Curriculum vitae* of Dr. Stewart McKinnell

MS. BAKER: Thank you.
Q Now, Dr. McKinnell, you have a Ph.D. in Fish Biology?
DR. McKINNELL: Correct.
Q And reviewing your c.v., you're currently the Deputy Executive Secretary for the North Pacific Marine Science organization also known as PICES?
DR. McKINNELL: Yes.
Q And you actually began at the head of Scientific Computing with the Pacific Biological Station at the Department of Fisheries and Oceans in 1981?
DR. McKINNELL: Yes.
Q And you've held positions as a fish biologist since then, first, following your head of Scientific Computing at Pacific Biological Station, you then became the principal investigator of ecosystem effects of large-scale Asian driftnet fisheries at DFO?
DR. McKINNELL: Yes.
Q And following that, you were the program head for Fisheries Production and Variability at DFO?
DR. McKINNELL: Yes.
Q And you left DFO in 1999 to move to your current position at PICES?
DR. McKINNELL: Yes.
Q And over the years, you have done research and presented papers and presentations on a variety of subjects involving marine life in the North Pacific Ocean?
DR. McKINNELL: Yes.
Q And just to highlight in your c.v., at page 3, I think it is - the pages aren't numbered - next page. You've received research grants studying marine life in the North Pacific which you see there, "Census of Marine Life" grant?
DR. McKINNELL: Yes.
Q And then just reading down a couple of other highlighted points here, you received from Canada GLOBEC research money to do research on the Gulf of Alaska Zooplankton Intercalibrating the

SCOR/NORPAC/Bongo nets?
DR. McKINNELL: Yes.
Q And you actually prepared a peer-reviewed publication following that research; is that right?
DR. McKINNELL: Yes.
Q You've also done work on density-dependent growth of juvenile Baltic salmon?
DR. McKINNELL: Yes.
Q And then flipping through to some of the work that you've done - next page, yeah, thank you - you've been editor of primary scientific literature on a variety of topics relevant to what we're dealing with in this inquiry including "Effects of climate variability on sub-arctic marine ecosystems"?
DR. McKINNELL: Yes.
Q "The ecology of juvenile salmon in the Northeast Pacific Ocean"?
DR. McKINNELL: Yes.
Q I won't read them all, but I'll move forward to the next page which sets out some of your peer-reviewed articles and book chapters. You have written on dynamics of marine ecosystems, which is the first paper listed under peer-reviewed articles?
DR. McKINNELL: Yes.
Q And the next one, Fraser River sockeye salmon and climate, a re-analysis that avoids an undesirable property of Ricker's curve?
DR. McKINNELL: Yes.
Q The fifth one seems particularly relevant, the ocean ecology of salmon in the northeast Pacific Ocean, and of course your c.v. goes on for many more pages which I'm not going to review.
MS. BAKER: Mr. Commissioner, I'd like to have Dr. McKinnell qualified as an expert in salmon biology and marine ecology with a particular expertise in the Pacific Ocean including the Gulf of Alaska.
THE COMMISSIONER: Yes. Thank you very much, Ms. Baker.
MS. BAKER: I'm going to move now to Dr. Beamish, and I'll move to Canada's list of documents for this c.v. It should be at Tab 11 of Canada's list of documents. Thank you. Again this is a multi-page document.
Q Dr. Beamish, you recognize this as your c.v.?
DR. BEAMISH: Yes, I think so.

DR. BEAMISH: Okay. I'll have that marked, please.
THE REGISTRAR: That would be Exhibit 1285.

EXHIBIT 1285: *Curriculum vitae* of Dr. Richard Beamish

MS. BAKER: Thank you.
Q And just quickly reviewing your c.v., you've got a Ph.D. in zoology, and I take it in fisheries?
DR. BEAMISH: Yes.
Q And you have a long career as a fisheries biologist, particularly with the Department of Fisheries and Oceans?
DR. BEAMISH: Yes.
Q You started at the Pacific Biological Station in Nanaimo in 1974?
DR. BEAMISH: I think so, yes.
Q All right. And you've been there ever since; is that right?
DR. BEAMISH: I started with DFO, though, earlier than that.
Q But you've been with PBS in Nanaimo since '74?
DR. BEAMISH: Yes.
Q And you've received a number of R.E. Foerster awards for outstanding scientific publications?
DR. BEAMISH: Yes.
Q You've also been awarded the Prix d'Excellence by Fisheries and Oceans for your contributions in fishery science; is that right?
DR. BEAMISH: Yes.
Q And that's been awarded a number of times including in 2008 and 2009?
DR. BEAMISH: Sorry, I couldn't hear you.
Q That's been awarded a number of times including --
DR. BEAMISH: Yes, yeah.
Q -- 2008 and 2009?
DR. BEAMISH: Yes.
Q And your work as a fisheries biologist has been looking at Pacific salmon generally for the most part; is that right?
DR. BEAMISH: No, I've done a lot of things including working on acid rain, and I worked on groundfish for a number of years, and am recently working on salmon.
Q Okay. And when you look at salmon, you've been looking at Pacific salmon as a whole, including coho, chinook, chum and other species?

DR. BEAMISH: Yes.
Q And you have a couple of publications that deal with sockeye, but most of your publications where they deal with salmon would be more focused on some of those other species like coho or chinook or chum?
DR. BEAMISH: That's mostly correct, but I probably have maybe five primary publications on Pacific salmon, and maybe a dozen or more others on -- sorry, five papers on sockeye specifically.
Q Yes.
DR. BEAMISH: Including one in Russia, by the way, in Russian. I didn't write the Russian. And then a bunch of other ones on sockeye too.
Q All right. And two of the ones that I've been able to identify that deal with sockeye are on page 9. You can correct me if I'm wrong on this, but the sixth article down, which is a publication with you and Sweeting and Neville which is actually called, "Improvement of juvenile Pacific salmon production in a regional ecosystem after the 1998 regime shift," actually does deal with sockeye salmon in that paper; is that right?
DR. BEAMISH: Yes.
Q Okay. And then on page 14, the fourth paper down, which is a paper you did with Neville and Cass in 1997, deals with production of Fraser River sockeye salmon in relation to decadal-scale changes in the climate and ocean?
DR. BEAMISH: Yes.
Q And, as you said, there are a few others as well that deal specifically with sockeye.
DR. BEAMISH: Yes, there's some other ones on sockeye somewhere.
MS. BAKER: Okay. Mr. Commissioner, I would like to have Dr. Beamish qualified as an expert in fish biology with particular expertise in factors affecting survival and abundance of fish including climate and oceans.
THE COMMISSIONER: Yes. Thank you.
MS. BAKER:
Q And finally Dr. Welch. Your c.v. is in Tab 2 of the Commission's documents. Do you recognize that as your c.v.?
DR. WELCH: Yes, I do.
MS. BAKER: I'll have that marked, please.
THE REGISTRAR: Exhibit number 1286.

MS. BAKER: Thank you.

EXHIBIT 1286: *Curriculum vitae* of Dr. David Welch

MS. BAKER:
Q Dr. Welch, you have a Ph.D. in Fisheries, Oceanography; is that right?
DR. WELCH: Correct.
Q And you also have received the Prix d'Excellence from Department of Fisheries and Oceans a number of times?
DR. WELCH: Prix d'Excellence once.
Q Pardon?
DR. WELCH: Prix d'Excellence was once.
Q Oh. And one is the Prix de Distinction.
DR. WELCH: Correct.
Q Thank you. And you've also received the R.E. Foerster Award for outstanding scientific publications?
DR. WELCH: Yes.
Q A number of times. And at page 4 of 4, you've given us a redacted version of your c.v. which just set out the most relevant publications to the work we're doing here today, and those publications are set out on the screen there at page 4.
DR. WELCH: Correct.
Q And they include your paper, "Thermal limits and ocean migration of sockeye salmon, long-term consequences of global warming," is the first one. "Early ocean survival and comparative marine movements of hatchery and wild juvenile steelhead as determined by acoustic array; Queen Charlotte Strait," correct?
DR. WELCH: Correct.
Q All right. And next one, "Survival of migrating salmon smolts in large rivers with and without dams."
DR. WELCH: Correct.
Q "Experimental measurements of hydrosystem-induced mortality in juvenile Snake River spring chinook salmon using a large-scale acoustic array."
DR. WELCH: Correct.
Q And the last one I'll just identify, "Freshwater and marine migration and survival of endangered Cultus Lake sockeye smolts using POST, a large-

scale acoustic telemetry array."
DR. WELCH: Correct.
MS. BAKER: All right, thank you. Mr. Commissioner, I would like to have Dr. Welch qualified as an expert in fish biology, fisheries oceanography and acoustic telemetry with particular expertise in Pacific salmon.
THE COMMISSIONER: Yes. Thank you, Ms. Baker.
MS. BAKER: Thank you. All right. Now I'd like to return to Dr. McKinnell.

EXAMINATION IN CHIEF BY MS. BAKER:

Q Dr. McKinnell, you have prepared a technical report for the Commission of Inquiry which is described as "Technical Report 4, The Decline of Fraser River Sockeye Salmon in Relation to Marine Ecology".
DR. McKINNELL: Yes.
MS. BAKER: Could I have Technical Report 4 pulled up, please?
DR. McKINNELL: Just for clarification, it was a report generated by the North Pacific Marine Science Organization where I was the lead author, one of several.
MS. BAKER:
Q All right, thank you. I'm going to take you to the c.v.'s of the other authors once we get this on the screen.
MR. LUNN: It's not listed on the Commission's list of documents, is it?
MS. BAKER: Technical Report 4?
MR. LUNN: (Indiscernible - not at microphone).
MS. BAKER: It's possible.
MR. LUNN: I'll need just a moment just to get that for you.
MS. BAKER: Sure, okay, no problem. While you're getting that up on the screen, I can at least identify the authors. Is that going to cause you a complication if I ask you to go to c.v.'s while you're trying to do what it is you're doing?
MS. TSURUMI: It's number 3 on our list.
MR. LUNN: There we go. I don't think this is it. Yes, it is.
MS. TSURUMI: It's not in colour.
MR. LUNN: I'll get a colour one for you while we're...
MS. BAKER: Okay. All right, thank you.

Q So the authors of this report -- as you said, you're the lead author, but the other authors are Enrique -- I'm going to butcher his name I think.
DR. McKINNELL: Curchitser.
MS. BAKER: Thank you. Cornelius Groot - I'll butcher the next name as well - Masahide Kaeriyama, and Katherine Myers. And those c.v.'s, just to identify them for the record and mark them, Tab 8 is the c.v. of Enrique Curchister (sic) -- that's not correct, I know how I pronounced it, but...
Q We can pull number 8 up so you can just identify that as his c.v.
DR. McKINNELL: Yes, looks like it.
MS. BAKER: All right. I'll have that marked, please.
THE REGISTRAR: Exhibit number 1287.

EXHIBIT 1287: *Curriculum vitae* of Enrique Curchitser

MS. BAKER:
Q And the next, Tab 9, is a biography of Cornelius deGroot (sic); is that correct?
DR. McKINNELL: Yes.
MS. BAKER: All right. I'll have that marked, please.
THE REGISTRAR: Exhibit 1288.

EXHIBIT 1288: Biography of Cornelius Groot

MS. BAKER:
Q And next tab, Tab 10, is the c.v. of Professor Kaeriyama.
DR. McKINNELL: Yes.
MS. BAKER: Thank you. I'll have that marked.
THE REGISTRAR: Exhibit 1289.

EXHIBIT 1289: *Curriculum vitae* of Masahide Kaeriyama

DR. BEAMISH: Thank you.
Q And then Tab 12 is the c.v. of Katherine Myers; is that right?
DR. McKINNELL: Yes.
DR. BEAMISH: Okay. I'll have that marked, please.
THE REGISTRAR: Exhibit 1290.

EXHIBIT 1290: *Curriculum vitae* of Katherine Myers

MS. BAKER: Thank you. I won't take the time to go through those c.v.'s but they are the c.v.'s of the co-authors of this report.
Q Because you're the first witness today, I'm going to ask you to just set some background information for us just to set the stage for what we're going to be talking about. We're talking about the marine environment for sockeye salmon in the Fraser River and I'd just like you to identify some of the areas that we're going to be talking about today.
If you could turn to Tab 37, which is actually Exhibit 2 in these proceedings.
MR. LUNN: I have multiple documents for Exhibit 2. There's a Powerpoint --
MS. BAKER: It's a Powerpoint.
MR. LUNN: Okay.
MS. BAKER: And it --
MR. LUNN: Oh, I see. The others are supplementary.
MS. BAKER: Okay. So if you could turn to page 4 of that Powerpoint?
DR. WELCH: Ms. Baker, that's the wrong presentation. That's mine from --
MS. BAKER: That's right. That's what I want to go to. I just want to go to the map on page -- maybe it's the next page, page 5. I have it as 4 but it could be 5. There. All right, yes.
Q So this was presented in evidence by Dr. Welch in October, but I think it's just useful as an overview to identify the areas we're going to be talking about, so if you could identify for us the main marine habitat areas for sockeye salmon from the Fraser River.
DR. McKINNELL: Sockeye from the Fraser River enter the ocean at Georgia Strait, Strait of Georgia, and emigrate by one of two routes along the continental shelf. They exit either by the Juan de Fuca Strait or via Queen Charlotte Strait, Broughton Archipelago.
As far as is known, most of them emigrate via the Queen Charlotte Strait route. Most sampling has found that the juveniles are migrating northward along the continental shelf, which you see is the lighter blue area on this particular figure, through Hecate Strait, up through southeast Alaska and generally have a restricted distribution along that region until they reach

Alaska.
At least the historical studies, when this was looked at in the 1960s and 1970s, came to the conclusion that as they were migrating westward along the Alaska shelf, they were eventually peeling off into the deeper parts of the North Pacific. The distribution of Fraser sockeye extends approximately to the dateline, 180 degrees, and generally is north of about, I would say, 50 degrees north latitude. So they occupy the region in the North Pacific known as the sub-Arctic Pacific. South of that, you have a transition zone into the sub-tropical regions and Fraser sockeye do not go into that region.
They spend the next several years -- well, depending on what kind of animal they are -- some of them mature in the following year, they do not migrate as far and they return after one year at sea. Some of them spend one, two and three years at sea. The bulk of Fraser River fish return after two years at sea. They feed in this sub-Arctic part of the Gulf of Alaska.
Q Right. If I can just ask you, then, just in terms of the actual areas that we're going to be talking about today, the Strait of Georgia on the map that you see in front of you would go from where the words are printed "Juan de Fuca" up just to where the words are printed, "Johnstone Strait, Discovery Pass"; is that right?
DR. McKINNELL: Yes. I would take it from just south of the Fraser River, Haro Strait, which isn't labelled here, up to, say, Redonda Island which isn't labelled. But Discovery Pass, that would do.
Q All right.
DR. McKINNELL: The lower part of Johnstone Strait.
Q And then when people talk about Queen Charlotte Strait today, which area are they talking about?
DR. McKINNELL: To be precise, they would be talking about a region that extends from approximately -- well, it's hard to describe on this graph, but it would be the upper part of the narrow ocean between Vancouver Island and the Mainland. That's essentially from probably Port McNeill or -- if I had to describe where Queen Charlotte Strait ends, it's probably around Telegraph Cove, if you've ever gone whale-watching up there.

Q So at the top of the Island, Vancouver Island?
DR. McKINNELL: Yes. Queen Charlotte Strait is the region where Vancouver Island and the Mainland start to diverge. They start separating after being in a narrow channel, which is Johnstone Strait, it starts to open into a wider area, and that's Queen Charlotte Strait.
Q All right.
DR. McKINNELL: And then it opens into Queen Charlotte Sound which is the broader region.
Q Okay. That was the next area I wanted to go to. The diagram we have in front of us has Queen Charlotte Sound printed out in the ocean, but that's actually just to the -- where you see the "d" on "Sound", it's the area just above that?
DR. McKINNELL: Precisely.
Q Okay. And it goes right to the bottom of Haida Gwaii; is that right?
DR. McKINNELL: Well, technically I don't know where you would --
Q Draw the line?
DR. McKINNELL: -- draw the line. But eventually, when you get into the part between -- a strait is a region between two bodies of land, and so Hecate Strait, I would assume, is the part between Haida Gwaii and the Mainland.
Q All right. So we often refer to Queen Charlotte Sound and Hecate Strait as sort of this one continuous mass of water from the top of Vancouver Island to the top of Haida Gwaii to --
DR. McKINNELL: I mean, certainly the water mass is continuous. The topography differs.
Q Okay. Then we also will hear about Dixon Entrance, and is that just at the top of Haida Gwaii?
DR. McKINNELL: It is.
Q Okay. And then on this diagram, there's a lighter blue that follows the coast and then a darker blue that's more in the ocean. What's the significance of that demarcation?
DR. McKINNELL: That's the continental slope. So it's a region where the ocean becomes much, much deeper very quickly over a short period of time.
Q All right. And how much is known right now -- and when I talk about this, I don't mean you in particular but just in the science community, how much is known about the length of time sockeye

spend in each of the different areas we've just talked about?
DR. McKINNELL: I think that is relatively well-determined. I mean, certainly the recent work that's been done, say, by the Department of Fisheries in the last ten years is getting a much better handle on the juvenile migration out of the Fraser River and poleward along the west coast up through Hecate Strait, Hecate Sound.
In general, their findings are not all that different from what was described, say, in the '60s and '70s, but they're getting much better resolution on the timing and the fish stocks involved. So that has been improving.
Alaskans are working on the continental shelf off southeast Alaska, and so there's a region there where the sampling of juvenile salmonids has improved. It's done in conjunction with a pollock study that's going on along that area.
But as you go around and get later into the season of the juvenile salmon, what you find is that the period between when they are migrating on the continental shelf and the period when they appear in deep water, that's probably one of the least well-known periods of time or areas of migration for these animals, in part because winter sampling is involved.
Then there's the period of feeding in the open ocean and, as I say, that can last -- these immature salmon can feed there, for Fraser sockeye generally, two years and return as maturing fish through the sub-Arctic region.
Q How much is known generally about how important each of these different habitat areas is to sockeye survival relative to the other?
DR. McKINNELL: Well, that's a good question. In general, the assumption has been that most of the mortality occurs soon after they enter the ocean. But in fact this has rarely been measured for Fraser River sockeye. To estimate the mortality, you need to have a census of abundance at time "x", and then the census of their abundance at time "x plus 1", and to note the difference in the abundance between those two periods. This will vary by stock within the Fraser because each has its own unique characteristics. Those repeated measurements where you have a representative

sample of abundance are generally, even throughout their lifespan into adulthood, not available.
Q Okay. What about food requirements for sockeye throughout this life cycle that they spend in the marine time, do the food requirements vary for sockeye during their life cycle?
DR. McKINNELL: Certainly they vary with season. If you look -- Dr. Beamish did a study on coho salmon where it showed that within Georgia Strait, what everybody was eating in April was pretty much similar between years, and what everybody was eating in September was pretty much similar between years. But the diets changed between the early sampling and the later sampling.
The same kind of pattern holds for sockeye. When they leave the Fraser River, they're only large enough to capture certain kinds of prey. Their mouth gape isn't large enough, so they tend to feed on certain kinds of items. But salmon are very opportunistic feeders and so it's not as though if a certain prey is missing, they will spend a lot of time seeking it out. They will choose alternative preys as they're migrating through the ocean.
MS. BAKER: In the report that we looked at initially, which is Technical Report 4 - if we can just get that pulled back up - first, I should have this marked as the next exhibit.
THE REGISTRAR: Exhibit 1291.

EXHIBIT 1291: Cohen Commission Technical Report 4 - Marine Ecology - Feb 2011

MS. BAKER:
Q In this report, you were asked to answer two questions, the first being: Do marine conditions explain the 2009 decline, and secondly, is there evidence of declines in marine productivity or changes in Fraser River sockeye distribution which are associated with declines over the last 15 years. Those were the two big questions you were asked.
DR. McKINNELL: Yes.
Q All right. So I will get to those questions, but in your report, you go through the state of knowledge of a number of different features of the marine environment over different life cycles, and

I just wanted to review some of those overview points before we come back to the questions.
So if I can just start in Chapter 2 of your report. It deals with the post-smolt year and looks at migratory routes and timing and speed and things like that, for that year. First of all, what are post-smolts?
DR. McKINNELL: I wanted to have a precise terminology for the period of time or life history stage that I was looking at. So, in this report, what you should be aware of is that most of the juvenile sockeye that rear in nursery lakes in the Fraser watershed go through a process called smoltification. That's a physiological preparation for life in the sea and is part of the package of migration and changing. They're getting their ability to regulate salt balance in the different environments established.
So the smolt phase I considered to be the period when, through this process of migrating to the mouth of the Fraser, and then the post-smolt process to be the year they enter the sea, so from the time they enter Georgia Strait through to the end of that calendar year. So in this report, when I refer to a post-smolt, it's after they - post means after - so it's after they've smoltified and entered the sea. I considered that to be the post-smolt phase up to the end of that calendar year.
Q So to the end of December.
DR. McKINNELL: Yeah. And from that period, from January 1st, I considered that to be the immature period. So an immature period is the period where they are spending the entire year feeding without maturing.
Q Okay. Well, let me stay with the post-smolts --
DR. McKINNELL: Okay.
Q -- and then we'll get on to the next ones. I'll just make a note of that there.
So when you looked at the post-smolt year phase, you referred to smolt migration timing, and you used Chilko smolts for that analysis. Why did you use Chilko smolts?
DR. McKINNELL: Chilko Lake is one of the few places in the Fraser watershed where the timing of their emigration from the lake and their abundance as they leave the lake is measured - or at least

estimated - and so this has become rather common practice to use the only substantially long time series, and that's Chilko Lake, so I used that.
I also used it because in 2010, at least for some of the timing work, acoustic tags were being placed on this Chilko Lake fish, or at least the larger ones as they were emigrating out of the lake. So going over the arrays that Dr. Welch is involved with, you were able to determine exact times for at least the tagged fish.
Q Okay. I don't want to get bogged down in too many details because your report is very clear, but I just wanted to -- and then we have talked about some of this already -- but when you look at the post-smolt time of life, what is understood about the migration route and the timing of Fraser River sockeye post-smolts?
DR. McKINNELL: Generally what you find is that the post-smolts will enter Georgia Strait somewhere around the beginning of May. Certainly there were sockeye in Georgia Strait in late April in some of the sampling that was done in the 1960s. But the bulk of them are coming down into the southern strait in May and they migrate rapidly. Most of them migrate rapidly northward, although I note that in the 1960s there was an abundance of post-smolts in Saanich Inlet even. So the routes northward in Georgia Strait will vary from year to year, at least from the sampling that has been done to date. Dr. Welch could probably provide some more details on that, of what he's found with the tagging.
Q Are there any particular stocks within Fraser River sockeye that enter the Strait of Georgia later than May?
DR. McKINNELL: Nobody has ever actually sat off the mouth of the Fraser River watching things come out of it, to my knowledge. But, in general, it's felt that the eco-type that is born in the Harrison River emigrates later because they do not spend a year or two in fresh water. They hatch and emigrate to sea in the same year, a behaviour that's very much like pink or chum salmon.
Q All right. And what is known about feeding habits of post-smolts?
DR. McKINNELL: The post-smolt diets, at least such as I was able to find, indicated that if they are in

the Strait of Georgia in April, the predominant dietary item was copepod. But there aren't that many sockeye smolts that have been sampled in April. They will eat decapod larvae, larvations, generally small planktonic animals that are in the water column and that will fit in their mouth, small euphausiids. Is that enough?
Q That's great. Have there been changes in the available prey for post-smolts, Fraser River post-smolts in the last 15 years?
DR. McKINNELL: I think if we choose to focus on the word "available", I would point out that most sampling of the planktonic environment involves net tows that go from depth to the surface. So they integrate over a water column from the very bottom, or at least from depth up into the surface, where as the sockeye are migrating through a planktonic field that's very near the surface. I believe Dr. Beamish's results indicate that most of the fish are caught in their zero to 15-metre layer. Most of the sockeye are caught in the zero to 15-metre layer from his sampling.
It's actually rather rare to have plankton that are available to them studied in this way. What you often see are the stomach contents from sampling, so you know what they picked. You know what went into their stomach, but you don't necessarily know what the available prey field was.
Q Okay. And have there been changes in what's been observed over the last approximately 15 years?
DR. McKINNELL: I would say yes, based on my discussions with planktologists who are looking at this region. In fact, it would be a surprise that there haven't been changes in some sense. The plankton community is very, on orders of magnitude, differences (sic). But there are low frequency trends and I know that one of the most common copepods, for instance, is the neocalanus plumchrus. It has been reported to be in lower abundance in recent years than it was historically.
But if you go back to the early 1970s, there was a copepod called calanus marshallae that was in quite high abundance during a very cold period back then.
Q Okay. In your report at pages 25 to 28, you

review the growth of Pacific salmon generally, and there's graphs and tables relating to chinook, chum, coho and pink, but there's nothing directly relating to sockeye salmon, so how is this section relevant to Fraser River sockeye salmon?
DR. McKINNELL: Well, the sockeye would be there if Dr. Beamish had published it in the paper that I extracted this information for. But, at the time, he felt it was difficult to interpret the sockeye data, and so it wasn't published.
What I wanted to do in this section was to at least show you how the patterns differ among the years for at least the species that were reported. I also wanted to show in here the uncertainty in the mean values that were reported. In this particular graph that's on page 27, here you see a sampling from 1997 when the Strait of Georgia survey started through to 2002. What was reported in the paper were the individual dots in the middle of those lines, but no indication of how uncertain those mean values were, were presented. But fortunately, a table was prepared that allowed these to be computed.
What you can see from the coho table, for example, in the bottom left, is that if you can draw a horizontal line that crosses all of those individual vertical lines, you can say that they are not statistically different, and so in this case, it shows that the mean lengths of the coho that were sampled were not statistically significantly different from '97 to 2002.
Whereas you can see that for the chinook plot in the top left, 1997, they were significantly smaller than the ones in 1998. That was the point of including these data was to show the kinds of variability that one could get from these Georgia Strait samples.
Q All right. And just how does that relate, then, to Fraser River sockeye?
DR. McKINNELL: Well, in fact there are four different species so we don't know exactly how they relate to Fraser River sockeye. Each species has its own behaviour. It's evolved its own characteristics and feeding habits and has its own diets. So what you could infer from Fraser River sockeye from these plots is not clear.
Q Okay. Is the current status of scientific

knowledge of post-smolt migration and distribution adequate? Do we know enough or is there still work to be done?

DR. McKINNELL: I would suggest that given the debates we've been having on various topics relating to timing, migration, abundance, that there are still many uncertainties that need to be resolved.

Q And the next phase talks about immature sockeye. You've told us the life time that that is referring to in your report, and maybe you can just go through some of the same points. What is known about the distribution and migration routes of immature sockeye?

DR. McKINNELL: As I mentioned before, this is what I considered to be the least well-known life history phases for sockeye, and so there are some things it was possible to understand from the high sea sampling in the 1960s and 1970s. But I think one of the things that becomes very evident when you look at this data is that the immature fish on the high seas have been under-sampled. And there are challenges to sampling. I know Dr. Welch here was involved in some winter cruises to go out and look at the immature phase in the Gulf of Alaska, and had tremendous difficulties finding them with the gear that they were using.

Likewise, the Japanese vessels have taken winter cruises looking for immature fish and found remarkably few using the gears that they're currently using.

So my view is that the life history of immatures is not well determined. There have been, at least when the early diet studies were done, there was evidence that the diets of the immature fish were considerably different from the diets of the maturing fish that were out there. They also found, from the tagging data that's been done, that the immature fish tended to have an average distribution which was further south than the maturing fish.

But this might be a consequence of the maturing fish having to get home. Because once you start maturing, you have to undertake your homeward migrations and so the extent to which the immature fish have a true distribution in winter that's different from the maturing fish is not clear in my mind.

Q Are density-dependent effects possible for immature Fraser River sockeye?
DR. McKINNELL: At that stage, it's hard to determine exactly, because density-dependence, first, is the idea that animals are affected by their own abundance. So in my report, I have identified intra-specific density dependence and inter-specific density dependence. Intra-specific means that sockeye abundance affects the sockeye growth or survival. Inter-specific means that the abundance of other species affects the sockeye size and survival and growth.
This has been shown for Bristol Bay sockeye, for Alaskan sockeye, that the abundance, the very high abundance of pink salmon from eastern Russia has an effect on the growth of the sockeye from Bristol Bay.
I'm not sure of any studies on immature Fraser River sockeye where that's been looked at. One of the difficulties is that nobody has measured what the immature abundance is. If you don't know the immature abundance, then how can you know if it has an effect on the immature stage?
Q Is climate change a feature that could have an impact on immature Fraser River sockeye?
DR. McKINNELL: Absolutely, but I would not want to guess whether it would be positive or negative at this stage without doing some research.
Q Okay. What kinds of effects could be seen?
DR. McKINNELL: Well, for instance, one of the things I want to first express on the climate change issue is that you've probably heard of the IPCC analysis and the projections of future climate and those sorts of works that have been done for which Nobel Prizes were awarded, and there is currently an assessment going on now.
What you find in these global climate assessments is that regional representations -- there are difficulties representing the finer scale climate, say, within British Columbia or the Gulf of Alaska, and that you find variability among the different models. So I wouldn't be comfortable, first off, saying that I know what climate changes will occur in British Columbia and what the response of the marine ecosystem will be in the northeast Pacific, because I don't think

the models are yet at the stage where they can accurately get the places, the precipitations right, and those sorts of things.

And so one can imagine that if you're an immature sockeye in the Gulf of Alaska and that the climate change allows perhaps for an earlier timing of the spring bloom, that the spring bloom is a period in the ocean when there's productivity, biological productivity, food available, you can imagine that that might improve the growth of sockeye.

On the other hand, if the climate change increases the winds and delays the spring bloom and keeps the region cold with lower food abundance, that that potentially might have a negative effect. So I would say that this is an academically interesting topic right now.

Q Is it an area that requires further research and understanding?

DR. McKINNELL: If you want a better answer from me, I think it does.

Q Does the scientific community have more information on that or does the scientific community need more research to be done on that issue, on climate change and impacts in the time frame that these immature sockeye are in the marine environment.

DR. McKINNELL: Well, my impression is that climate effects seem to dominate our discussion of the biology of salmon. It's interesting that we don't talk so much -- in the scientific community, we don't talk so much about fishing or other effects that could affect the salmon. But maybe that's just the group I'm involved in. The focus of the research is trying to understand these climate variability effects on survival and growth.

Q So it is important.

DR. McKINNELL: Absolutely.

Q All right. And is it your view that further work -- well, let me just ask it this way: Is the current state of scientific knowledge as to the impacts of survival of immature sockeye adequate at present, or do we need to do more work in that area as well?

DR. McKINNELL: Well, "adequate" is kind of a value judgment. If the interest is in improving our understanding, then I would say, no, it's not

adequate.
Q I'd like to move to maturing sockeye, so that's in Chapter 4 of your report. Just continuing that line of questioning, what's known about the distribution of maturing sockeye and what's the time frame, I guess, of their life that you are referring to when you talk about maturing sockeye.
DR. McKINNELL: Yes. As I said before, the immature phase on the high seas can last one, two, and some cases - rarely - three years for sockeye salmon. Let's just focus on the fish that return after two years at sea. So after their one immature year, it's my understanding that the go/no go on maturity is established in the winter preceding the year they will mature. So a physiological decision would have been made in the fish that it's time to mature and time to come home. There's a genetic component to this and there's a growth component to this.

From that stage on, the maturing fish have a different life from the immature fish. They have to find enough food to put on -- probably 50 percent of their weight is put on in that last spring at sea. So there's a huge energetic demand on the maturing fish that does not exist for the immature fish, because they have to be able to have enough resources to get from the Gulf of Alaska to fresh water, to swim up the rivers, to mate and produce gametes and everything that goes along with maturation. That's an energy intensive-process.

So they end up with different behaviours as a consequence of this. The one that we notice the most is the migration behaviour, because we see them start moving closer to the coast and the fisheries take advantage of that when they get to the coast.
Q And what do we know about their feeding? You say that they have this energetic demand. Do we actually know what they're eating during that life phase?
DR. McKINNELL: The studies that I've seen so far indicate that the prey item that's found perhaps most commonly, at least in the southern part of their range, is a small squid. It's energetically rich and tends, if you look at page 53 - this is the contribution by Masahide Kaeriyama - where you

can see one colour tends -- this is sampling of stomach contents in sockeye on the high seas. One colour tends to dominate all the years from 1958 through to the present. That's the fraction of small squid. So you can see in this particular image, there is a very high fraction of the small squids there in the diet.

Although I would point out that the Fisheries Research Board sampling in the Gulf of Alaska in the 1950s - you see the 1958 data there - if you actually look at what they found in the northern Gulf of Alaska, they found higher fractions of fishes in the diets. It was in the more southerly regions in the Gulf of Alaska where they found these high concentrations of squid. This is what Masahide Kaeriyama has found with his work here.

Q Okay. The next section in your report following the table you just took us through are the next two sections over, it's called "Trends" and it looks at growth size. You say, on page 57 underneath the heading, "4.3.2 Trends" that -- first of all, you're describing trends in the mean size of Fraser River sockeye in relation to increasing sea surface temperatures and you say that "there is a significant low-frequency variability in mean size." What is that referring to?

DR. McKINNELL: If you could go to the previous page --

Q Where there's a table, Figure 35?

DR. McKINNELL: It's a figure, yeah, Figure 35. Here, each panel represents a different age class. I believe the top one is the fish that return after one year. The middle panel is the most common one; these are fish that return after two years. The bottom panel is fish that return after three years at sea.

When I say "low-frequency variability", what you'll notice is each - let's just go to the very top one - there are a series of about 16 trend lines through that figure, and those represent the trends of these stocks over on the right-hand side and these have been measured on the spawning grounds.

So what you see is that by a low-frequency trend, I mean a trend that doesn't change very quickly. So generally you see the length anomaly on the "y" axis. It represents the number of

centimetres higher than the long-term average or lower than the long-term average. So, as we go along, most of those lengths prior to the mid 1970s are above the average, and then there was an abrupt shift to sizes below average. In recent years, these trends have started to come back up. So low frequency is the idea that you have slowly varying changes in mean length in this case.
Q All right. And just going back to the paragraph I was reading from earlier, you identified that there had been this downward trend and you say that it was from '52 to '93, there was a decrease in mean size. Then you're now seeing that starting to go up since '93?
DR. McKINNELL: Yes. The mean size has started to increase. You look at most of those trend lines, it wasn't back up to a zero anomaly, but it was increasing.
Q What's the significance of that?
DR. McKINNELL: The significance of that is smaller sockeye tend to have smaller eggs. In general, large size is said to confer on an individual better fitness, and fitness in the sense that your genes will survive because you are more robust. So I guess, in part, it's one of the long-term implications of sea surface temperature is that it does affect the biology of the spawning fish that are coming back to spawn.
Q Was there a corresponding change in sea surface temperature, then, from '83 to the present?
DR. McKINNELL: Yeah, if you look at Figure 36 on page 58, this is a map that shows the correlation between sea surface temperature and the grand mean size of all the sockeye that were coming back to the Fraser. This is essentially a look at how sea surface temperature and the overall mean length varies from year to year. The reason I chose only from 1993 to 2007 was because this was after the period when Dr. Cox and Hinch had found that there was this kind of relationship, I wanted to take the more recent data and say what kind of correlations do we see.
Anywhere where it's blue or purple in this plot means that increasing temperature means decreasing size. So what you see, this relationship, because we have a grid of temperatures available through time over the Gulf

of Alaska, you can make these comparisons from year to year. So if the Gulf of Alaska gets warmer, the sockeye get smaller.
Q Okay. That's pretty simple. We can probably understand that concept.
You next, in this section dealing with maturing sockeye, again deal with the density-dependent issue, again inter and intra-specific. What are the issues, I guess, with respect to density-dependent growth in maturing sockeye? What has been observed and what does it tell us?
DR. McKINNELL: Yeah. Most of the studies of density-dependent growth in sockeye have identified that it is the year when the fish mature has the greatest effect on the mean size of the fish that return. So I've just previously talked about the influence of sea surface temperature. There's also another effect which is the abundance of the fish. When the abundance of the fish is high, their mean size tends to be low.
When this effect occurs seems to be in the last year at sea in the year that they are maturing. Because two fish from the same brood year that return in different years, their mean sizes are not correlated, but two fish from different brood years that return at the same size, their sizes are correlated.
Q You said "when they return at the same size". You meant return in the same year?
DR. McKINNELL: Sorry, yeah, when they return in the same year. So the dominant effect is the abundance in the year when they mature. That's when the density-dependent growth is in evidence, and it's been in evidence -- well, I put the quote up here on the screen here. Charles Gilbert thought of this in 1914, or at least wrote about it. The first studies on this were done in 1980. Don Rogers reported this.
Q And is there a difference between inter-specific effects or inter-species effects and intra-species effects?
DR. McKINNELL: Absolutely. So then we have to look at the effects on Fraser River sockeye, how are they affected by the abundance of other species? I'm aware of studies in Bristol Bay where there's an apparent effect, but I can't recall whether that's an effect on maturing Fraser River sockeye,

whether there's an inter-specific effect on Fraser sockeye.
Q Is this an area that requires further analysis, further work?
DR. McKINNELL: Actually, this should be -- it may have been done. It would surprise me if it hadn't been done, but I just can't recall an example right now.
Q Is there a better understanding of the maturing phase of sockeye salmon that, for example, the immature phase where you said there was very little understanding of that phase?
DR. McKINNELL: If I -- yes, I would say yes, and I would say yes simply because the maturing fish were more vulnerable to the gear. They're the animals that are caught in fisheries and they're the animals that escape to the rivers. So I would say we know quite a bit more about them than we do about the immature fish.
Q Right. Is it an area that requires further research or have we --
DR. McKINNELL: I think you have to have a specific question. If you have a good question, then I think, yes, we need to do more research.
Q Okay. The next section of your report deals with survival, which is Chapter 5. First of all, how is survival currently assessed for Fraser River sockeye? For example, is it assessed for total survival, total returns or survival with respect to different life stages?
DR. McKINNELL: It's my understanding that there's a variety of methods used to assess survival in Fraser River sockeye. I mean, there are many, many populations. The most common one is what I've called here "Total Survival", which is a census of the population when they are spawning, and a census of the population when you see the children of that spawning return. So then you get a sense - based on some assumptions about how many eggs were produced - you get a sense of what the survival through their whole life cycle was. That's the most common method of estimating survival in sockeye.
Q All right. And does that kind of total survival assessment allow us to understand the different life stage impacts on survival?
DR. McKINNELL: Absolutely not. The point is that if

you want to understand -- survival is a change in abundance in a period of time. Right now, you have the period of time is one complete generation. If you actually want to understand where survival is being affected, you need to census the population at different periods in time. This is the example with the Chilko fish where they census the population of smolts leaving the lake. So all of the mortality in the lake has occurred and you see what is leaving the lake. So it's one of the few populations where you get this intermediate value. But, in fact, that isn't adequate to partition it even finer.
Q All right. And what would be needed to allow that further partitioning?
DR. McKINNELL: Well, let me say that when I had my chapter out for review, one of the reviewers said you in fact have no estimates of marine survival, which is in fact true because, to get that, you would have to census the population at the mouth of the Fraser River.
What we have is a census of Chilko fish anyway at the outlet to the river. It's much more convenient to do it there.
Q So if you had a census at the mouth of the Fraser, that would allow you at least to have --
DR. McKINNELL: It would at least allow you an honest partition between the freshwater survival and the marine survival. But you need to do it by stock. You cannot just take a collection of genetically different animals, put them in a pool and assume that they share common characteristics. You need to understand stock-specific abundances.
Q Could that be done with sampling at the mouth of the Fraser?
DR. McKINNELL: In theory.
Q And then what about the other phases? We've been talking about post-smolt, immature and maturing. Do we need to further partition --
DR. McKINNELL: Well, one of the debates that has gone on for at least a year now is about whether there was additional mortality in Georgia Strait or not. One way to solve that problem would be to have a census at the exit to George Strait, and then one would know what came out and what didn't come out.
Part of this has been done. I would say it's a pilot study by Dr. Welch's tagging work with his

colleagues, but I don't think that would be adequate for an assessment of the kind we're talking about.
Q But that would still only help us understand what happened in the Strait of Georgia. It still wouldn't help us understand the next two phases.
DR. McKINNELL: Absolutely.
Q Okay.
DR. McKINNELL: So then you'd have to look at establishing a way of censusing the Fraser population perhaps as it migrated along the continental shelf. One of the challenges to that is you don't know where exactly they come off the shelf, so you might have fish swimming off the shelf that you interpret as a reduced population size, but in fact they're just leaking off the continental shelf where you assume that they're living.
Q Just maybe the last question before the break. When you looked at what information you had available for this section, you did look at survival of Chilko in fresh water versus the ocean. What did you find when you did that assessment?
Sorry, if I can just stop for a minute, you also looked at the different age classes in Chilko as part of that work. What did you find?
DR. McKINNELL: I was interested because, in general, there's a feeling that larger individuals survive better than smaller individuals, and the older age classes of smolts, the two-year olds, two-year-old smolts from Chilko Lake are larger, on average, than the one-year-old smolts. So this gives an opportunity to -- you almost have a replicate. You can look at what's going on with the older smolts and what's going on with the younger smolts.
Certainly one of the things that we found in this report - and I think there's a figure here --
Q Is that on page 79?
DR. McKINNELL: Yes, it's Figure 50.
Q Page 79.
DR. McKINNELL: Yeah. This graph shows a weak positive correlation between the proportion of one-year-old smolts that eventually survive and the proportion of two-year-old smolts that eventually survive. If they were perfectly correlated, they would lie

along a straight line in this graph, but of course they don't. There's lots of scatter.

But there tends to be a positive correlation between smolts of different ages that enter the sea in the same year, whereas there is no correlation in the survival between smolts of the same brood year that enter the sea in different years.

Q So what does that tell you?

DR. McKINNELL: It tells us that after leaving the lake, the one-year-old and two-year-old smolts tend to experience some of the same environmental characteristics. It says that the environmental characteristics that they experienced after they left the lake were shared commonly.

But you can see, because these points don't lie on a nice line, that it's pretty noisy.

THE COMMISSIONER: Dr. McKinnell, you may have answered Ms. Baker's question on this, and I may have just missed it. But in terms of taking census, getting a handle on numbers, you talked about Chilko and the reason why Chilko is used. Dr. Welch earlier has addressed, as Dr. Riddell did, the ability to place the tags and the technology around that science at the current time. But is there a more critical stage? In other words, do you have to have reasonably sophisticated census-taking in the freshwater stage - that is, when they leave the rearing lake and head out to sea - before you start focusing on assessment of numbers in Georgia Strait or after Georgia Strait? Is the first critical stage having a sophisticated methodology of assessing numbers as the sockeye leave the rearing lakes and head out to sea?

DR. McKINNELL: If you had suggested having that estimate at the mouth of the Fraser River, I would have agreed with you. Having that estimate as they are leaving the lakes would be better -- if we had more lakes -- certainly the most productive lakes. There are many lakes in the Fraser system that produce sockeye. But certainly to at least have the most productive lakes censused as they're leaving the lake would be good.

But it's my understanding that in-river mortality can be quite high, and so just because you saw the fish leave the lake does not necessarily mean that they popped out into Georgia

Strait.

THE COMMISSIONER: That's why I asked the question of when scientists are trying to get a picture painted of what's going on, is each stage critical to complete that picture, or is it more critical in the marine environment to do the work you're talking about than it is to spend funds in research of this calibre with respect to the freshwater migration of the fish -- out-migration.

DR. McKINNELL: I guess at issue, Commissioner, is where the greatest variability lies, and I think that there's certainly a lot of debate about where that location is. In the ocean environment, you will find that the early marine period is thought to be the time of greatest mortality. But I think there's evidence to suggest that it may not be, and in the absence of a good census, there will be lots of debate and not very many answers.

THE COMMISSIONER: And if I could just finish, in layman's terms - and I'm sure Dr. Welch and Dr. Beamish will address this - but you mentioned uncertainties that still exist in the marine environment, and that has been mentioned here frequently by your colleagues in the science field. But if you don't resolve uncertainties in the freshwater environment around the life cycle of the sockeye as it out-migrates, can you ever really tackle other uncertainties, be they in the marine environment or in the in-migration of the sockeye?

In other words, do you have to have each of these components reasonably well tested in order to complete your analysis of what is happening at the different life cycles of the sockeye?

DR. McKINNELL: Commissioner, I think that for most Canadians, the life history stage that's of most interest to them is the maturing adult phase when they return to the coast. The ideal census, from a theoretical point of view, is that why count them early on when what you're really interested in is how abundant they are in the final stages? The challenge is that that is technically very difficult at the current time to do that, but the further you get away from the life history stage of your greatest interest, the more variability you will encounter over the period that it takes for them to get there.

So that's why I would suggest that the mouth of the Fraser River might be a better place to do it because you've at least accounted for the freshwater mortality in the river. If you did it at the mouth of the entrance to Georgia Strait, say up where it narrows into Johnstone Strait, you would have accounted for the mortality up to that point.

So the question is what is your interest?

THE COMMISSIONER: Right. Thank you very much.

MS. BAKER: Would you like to take the morning break now?

THE COMMISSIONER: That would be great. Thank you.

(PROCEEDINGS ADJOURNED FOR MORNING RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: The hearing is now resumed.

MS. BAKER: Thank you.

EXAMINATION IN CHIEF BY MS. BAKER, continuing:

Q Turning to section 5.6.1 of your report, again this is in your "Survival" section. You make a comparison between coho salmon survival, and if you have a look at that, why is that relevant to Fraser River sockeye? Why did you make that comparison?

DR. McKINNELL: This would be coho in the Strait of Georgia and their survival. A few years ago we established a kind of an informal salmon sockeye -- or a salmon forecasting forum. A group of scientists on the West Coast who were interested in looking at the ocean and trying to figure out what it meant for the future returns of adult salmon, and trying to find leading indicators of their survival was the motivation for looking at the survivals of coho salmon in Georgia Strait.

Coho smolts and sockeye smolts go to sea in the -- from the same brood year, go to sea in the same year, but the coho return one year earlier. And so you can, if you're collecting the data, you can get an estimate of how the -- how well the coho salmon survived that year. And the advantage there is that they return one early year. You get an estimate of some salmon that went into the ocean environment, spent the winter, and then

returned, and you get a sense of their -- of their mortality or survival.
And this, the idea that it's a leading indicator, if there's any correlation between the sockeye, in my case I used Chilko sockeye, because that's the marine survival time series. I was interested in the forecasting the marine survival. You can get a leading indicator of what the Chilko survival would be. And the relationship between the coho survival and the Chilko sockeye survival for fish that enter the ocean at the same time is weak, but not -- but not zero. And so I felt that there was some advantage to examining what was happening with the coho.
Now, I should point out that there's no particular need to focus on the coho in Georgia Strait, because in fact the survival signal for coho salmon, the year-to-year survivals are quite correlated along the West Coast. What you find is that from Oregon, Puget Sound, Georgia Strait, so the -- whatever it is that's affecting the coho in Georgia Strait, there's an element of that that is shared by a lot of populations of coho on the salmon -- sorry, along the coast.
Q Salmon that don't go to the Strait of Georgia.
DR. McKINNELL: Yeah, salmon that don't even go to the Strait of Georgia.
Q And on the next page, page 84 of your report, you address forecasts, starting in 2007, that were based on Strait of Georgia surveys. Do you have any views on whether the conditions in the Strait of Georgia can be used to predict sockeye returns?
DR. McKINNELL: The reason I put this in here was just to point out that the several forecasts had been made, and anybody who does forecasting needs to assess the skill of their forecast. And the skill of their forecast is measured by its performance, repeated year after year. And in this particular case, a forecast had been developed from the Strait of Georgia surveys for three years in a row, each year I think perhaps using some different formula. But in two years the forecast was quite wrong and in one year the forecast was quite right. And so I was simply pointing out that that's something that could quite easily occur by chance.
Q The next chapter of your report deals with

"Oceanography and Climate", and you look at a number of different oceanographic features from the Strait of Georgia through to the Gulf of Alaska. Was your focus in this section to look at -- when reviewing these different features to look for extreme events, or general trends, or both, or something else?
DR. McKINNELL: Because the events of 2009, the low returns were such an extreme event, actually it was more extreme compared to the pre-season forecast than -- but, you know, that certainly brought this to a head. It was an attempt to look at the oceanography and climate of the Northeast Pacific in relation to whether anything like this had been seen previously. And so our approach was to seek out any evidence of extreme observations that would match the relatively extreme low survival for that particular year of sockeye.
Q Okay. And then I want to just go through each of the different geographic areas bit by bit.
DR. McKINNELL: Yes.
Q So the first geographic area that you talk about is the Strait of Georgia.
DR. McKINNELL: Yes.
Q You've already sort of identified the bounds of that today. Were there any extreme events that you saw in the Strait of Georgia in 2007, which would be the relevant year for the 2009 return; is that right?
DR. McKINNELL: Yes. In fact, in any of the figures that I've produced for the Strait of Georgia, looking at whether it was sea surface properties from 75-year-old time series at lighthouses, or recent surveys, oceanographic surveys done in Strait of Georgia, I didn't find any extreme -- values that were extreme across the entire length of observations. There were certainly some patterns in Georgia Strait that went along with 2007 being a relatively high year of Fraser River discharge, but in fact I think it was -- if you look at the discharge during the peak in 2007, it was something like the 17th highest year peak discharge in the record, which doesn't really constitute an extreme. And then we looked at its influence in the Strait of Georgia at various places where there are other long time series and didn't find extremes. We certainly found that

they were not average, but certainly not extreme.
Q Now, you talk a little bit about Nanoose hydrography in your report and I wonder if you could explain what that is and why it's relevant, what it told you.
DR. McKINNELL: The Nanoose station is unique in that it gives you a long-term idea of the vertical structure of the ocean in Georgia Strait. And so since about 1972 -- no, '79, '78 it allows, because it's done relatively frequently by the Department of National Defence and augmented by observations from DFO, it allows you a chance to look at the vertical structure of the ocean, which you do not get from many of the surface properties that are measured at lighthouses and other locations.
Q And what did the Nanoose hydrography tell you?
DR. McKINNELL: We looked at the surface, the density of the water column in the surface and found that -- that was the thing that we were most interested in, in the springtime was there anything anomalous about the density layer of the surface water, and we did not find anything.
Q And what does that mean to sockeye, density layer of surface water?
DR. McKINNELL: Ah, yes. Yes. Well, it's associated with something that's known as the mixed layer. The mixed layer of an ocean is a region that has common water properties, and it separates from the deeper water as a consequence of salinity. Decreasing salinity, or increasing heat will cause the upper layer of the ocean to stop mixing with the deeper parts of the ocean.
Q And do we need the layers to mix? Is there some significance to a mixing of these layers?
DR. McKINNELL: It is significant if one of two things happens. One is if the mixed layer prevents the supply of nutrients for plankton growth from reaching the euphotic zone, the region of the water column that has light, and where plankton, phytoplankton can grow. And so if the mixed layer is much deeper than the euphotic zone, the phytoplankton cells mix down into the dark areas where they don't -- they can't reproduce, or they can't create the fixed carbon that becomes part of the base of the food chain.
The other consequence of a mix of -- reason

for paying attention to a mixed layer is if as a consequence of a mixed layer being relatively shallow, it gets much warmer. You realize that if the ocean is mixing to depth, if you've ever been swimming in a lake, you stick your toes deeper into the water and you feel that cold down below. Well, the idea is that this -- the winds will mix this cold water up and -- but if you -- if you create a density layer, a much lighter surface layer, the atmospheric temperatures, you know, the heat from the day or will restrict the depth of the circulation of the ocean, such that only the top of it gets the heat. And so you can, as a consequence of that, in extreme cases, you end up with sea surface temperatures that are undesirable for sockeye salmon.
And certainly what is known about Fraser River sockeye with some certainty is that years when the surface layer is warm, are years when they enter the ocean, are years when the survival tends to be worse. And years when the ocean is cold, tend to be years when the survival is better.
Q Now, we will be dealing with four reports that were prepared by -- well, Dr. Beamish wasn't the lead off on all of them, but he was an author on all of them. And one of them is a paper by Dr. Thomson and Beamish, which we're going to get to later, but let me just identify it now so we know what we're talking about. And that you'll find that in the Commission's document book at Tab 14. So I won't mark this now, but I'll just -- just so that the Commissioner knows what we were talking about, we'll come back to this when Dr. Beamish is answering my questions. But this is a paper that's been prepared by Dr. Thomson, and you've read this report?
DR. McKINNELL: Yes. I believe this is an unpublished manuscript that was --
Q That's right.
DR. McKINNELL: -- but I have gone through it, yes.
Q And Dr. Thomson et al, they actually estimate a different mixed layer depth at Nanoose than you do. Do you have any comment on that?
DR. McKINNELL: Yeah, my comment is that I didn't actually estimate the mixed layer depth at Nanoose. There are many ways of doing this and

Dr. Thomson has his own particular method, but it's not in common use as far as I know. There are other methods that are more commonly used. But I didn't -- I didn't estimate the mixed layer depth.
Q All right. So how does your work then relate to the work that Dr. Thomson has done?
DR. McKINNELL: Well, probably the best comparison for Nanoose station is that at least I was looking for density differences between two layers, the upper surface layer I picked, I think, for one calculation I tried five metres, and for another calculation I tried ten metres. But the idea that if there's -- to figure out what the difference is between the density below five metres and the density above five metres, by computing the averages above and the averages below, and looking at the delta, the difference, because the delta will give you some indication of how -- how resistant the water column is to mixing. And then I did this across the entire range of years for the time series, and certainly found that in 2007 that the difference was relatively high compared to the average of most years. But I also found that other years were -- had similar values.
Q And what does that mean, when you say it was relatively high? What does that (indiscernible - overlapping speakers).
DR. McKINNELL: It just means that the water column was more resistant to deeper mixing than -- in 2007 than in other years. But it certainly wasn't the most extreme observed in the record. There are other years that were equally -- that had equal kinds of values.
Q All right, thank you. And then the next -- you can put that report away for now. Thank you.
The next part of your report addresses the coastal Gulf of Alaska. Now, that phrase, "coastal Gulf of Alaska" isn't one that we've really defined yet. So what do you include within the coastal Gulf of Alaska?
DR. McKINNELL: In my definition it's essentially what happens to the fish when they get out of Johnston Strait.
Q Until when? Does it include the whole open ocean area?
DR. McKINNELL: For the ocean, for the climate work, I

was looking mostly at southeast Alaska, from southeast Alaska, northern southeast Alaska down to Johnston Strait.
Q Kind of the coastal areas, as you've described it, coastal Gulf of Alaska, but not the open ocean.
DR. McKINNELL: That's right.
Q Okay. And were there any trends that you observed in sea surface temperatures from 2005 to 2007, trends or shifts?
DR. McKINNELL: Well, let's put it this way. The year 2005 was probably one of the warmest years in the surface ocean in the Gulf of Alaska generally in decades. 1997 is a year that comes close, but 2005 was an extremely warm surface layer throughout the Gulf of Alaska, including the coastal region. These warm temperatures started to abate in 2006, and between 2005 at the peak and 2008, which was one of the coldest years throughout the Gulf of Alaska in probably 35 years, there was a transition moving from warmer to cooler through those series of years.
Q Was there any shifts or any anomalies in sea surface temperature in 2007?
DR. McKINNELL: Yes, absolutely. In 2007 one of the analyses I looked at was to say where in the Gulf of Alaska over all time in all years is some of -- is an extreme value observed. And for the year 2007, the only most extreme values in the time series from 1982 occurred in Queen Charlotte Strait and Queen Charlotte Sound, for sea surface temperature.
Q And you have those on Figures 69 and 70 on page 107?
DR. McKINNELL: Yeah, the locations of those are -- where is that figure?
Q Is that page 130? I could be wrong.
DR. McKINNELL: Yes, that's right. So this was in 2007 the only place in the entire time series with an extreme temperature in the record since 1982 occurred in August in this location, in Queen Charlotte Strait/Queen Charlotte Sound.
Q Right. For the people in the room who may not be familiar with looking at these kinds of diagrams --
DR. McKINNELL: Oh, yeah. Okay.
Q -- maybe you can help us locate where maybe some landmarks are to help us on this.

DR. McKINNELL: Yeah, sorry. Now, this is, the plot here, of course, the blue parts are the ocean, the green parts are -- and brown parts are the land, and because the resolution is not so good, and what you see is the shading is the depth of the ocean or the altitude of the land. And the point I'm making is that that -- those three dots over in the right-hand side, yes, are located, are the three -- in the global sea surface temperature time series there is one of the -- a time series for every one degree latitude by one degree longitude block throughout the Gulf of Alaska. And this shows you the three grid points in that whole mesh or sea surface temperature histories where there was an extreme value, and it appeared in the summer of 2007.
Q And those are, as you say, in Queen Charlotte Strait or Sound?
DR. McKINNELL: I would -- the resolution is probably not good enough to distinguish whether Queen Charlotte Strait is included in this or not, but because the sea surface temperatures tend to have a spatial scale, a larger spatial scale, I would say that Queen Charlotte Strait is probably included in this.
Q And Queen Charlotte Sound.
DR. McKINNELL: Yeah. Oh, yeah.
Q Okay. Now, in the Queen Charlotte Strait or Sound, either of those, were there any anomalies in salinity observed in 2007?
DR. McKINNELL: Actually it was these three data points that led to an exploration of how -- how it would be that in a year when the entire Gulf of Alaska was generally supposed to be cold, we ended up with some positive extremes, positive high extreme temperatures in the record. And as I mentioned earlier, one of the ways that you can generate high sea surface temperatures is by having a freshwater layer on top of a -- or at least a less dense layer on top of a more dense deeper layer. And I have a figure in here --
Q Is it page 107?
DR. McKINNELL: We're going back -- so that shows the DFO survey that was going on as this anomaly was building up. It's on page 107, it's the bottom, well, both figures on that page, actually, we could look at. But the bottom one is a survey of

average temperatures across Queen Charlotte Sound, and that dot at the bottom of your plot on page 107 in the lower panel is 2007. Much, much, much fresher than anything that had been observed during the period before and after.

And if you look up at the top panel on that plot, this is a panel showing the salinity measured at Egg Island, which is in the eastern part of Queen Charlotte Sound. So what you see is a much less saline, much fresher layer in the surface than has ever appeared in the record.

Q And what does that mean for Fraser River sockeye?

DR. McKINNELL: Well, for Fraser River sockeye, you recall that one of the few things that's known about their inter-annual survivability is that in years when they go to sea in warm -- when it's warm, they do not survive very well. And so here was a region of warmth. For Fraser sockeye, I think it's debateable how this actually affected them, but on the --with the very simple understanding that's around in the scientific community now, I would suggest that that this would just be seen as an unfriendly environment for the fish to be swimming through.

Q And did you observe any anomalies in wind patterns?

DR. McKINNELL: In fact, we did. If you take -- and the wind patterns, let's just go to -- okay, this is Figure 72 on page 109. This is -- there is a global dataset that reports on wind speeds on the global basis, but it's possible to focus in on particular regions by picking a grid point in that global grid, and this one is very near Queen Charlotte Sound. And let me explain what you're seeing here. The wind speeds are measured in both east-west direction and the north-south direction. And the tendency is for winter winds to be blowing toward the west from the east. And so the winds that are -- the winds that are blowing toward the east are on the left side of the dashed vertical line. The winds that are on the right side are blowing toward the west, and that's the normal summer pattern.

And the normal summer pattern in this part of British Columbia is that in the summer time you get northwest winds with blue skies and, well, maybe not blue skies up there, but at least the wind patterns have this seasonal evolution from north-westerlies in the summer time, to south-easterlies in the winter time. And of course the north-westerlies are associated with transition to spring -- to the spring bloom, spring timing, which other people have found to be an important indicator in Queen Charlotte Sound.

So what you see is these are -- these are the points on this graph are from year-to-year averages in June and July of how these wind speeds, the average wind speeds in each year in June and July. And you see that 2007 is identified in that top left corner. So in the entire record of average wind speeds over Queen Charlotte Sound, the most extreme winter-like pattern, and these are southeast winds, or at least not -- yeah, so these tended to be southeast winds, winter-like winds, set up in 2007.

Well, one of the things that happens in the northern hemisphere is that southeast winds will retain the water within Queen Charlotte Sound. They will blow water in -- surface waters into the Sound. So you had this high -- this thick layer of freshwater coming off the coastal mountains into Queen Charlotte Sound that was being retained within the Sound by these very anomalous south-easterly winds in 2007. And as a consequence you ended up building up both because of the volume of the discharge coming off the mountains, and the wind patterns, you create the anomaly that we showed you before, which was the very low salinities in the surface layer of Queen Charlotte Sound and Strait.

Q Okay. So does it have any additional significance, then, for Fraser River sockeye beyond what you already described, which is that impact on the fresh layer?

DR. McKINNELL: No, I don't think so.

Q Okay.

DR. McKINNELL: I mean, just to, you could end up with the plankton community in that surface layer could be different, you know, the animals living in the surface layer that may not like the salinity or avoid the salinity could be their prey, and so there's an issue about how much it changed the food web. But you'd have to have done the tows in that layer to understand.

Q All right. And have you seen any changes between the conditions that you observed in 2007, any of the ones you've talked about today, and the conditions in 2008 in Queen Charlotte Sound or Strait?
DR. McKINNELL: If you look on page 111, in the top panel, the top figure, this shows the contrast between 2007 in the upper row, it's July, August, and September, across from left to right, 2007 is in the upper row, 2008 is in the lower row. Blue and purple colours are colder than the long-term average, and yellow and orange colours are warmer than the long-term average.
So what you see here is -- let's start with the top left panel, which is July of 2007. The Gulf of Alaska is generally experiencing this cooling trend that I've described before. But for some reason, the coast of British Columbia has this -- has anomalies that are slightly positive, the scale is on just the right of that. So they're up to half a degree, maybe even a bit warmer. The next panel over is August of 2007, and you see how there's a whole coast that's developed these positive sea surface temperatures anomalies while it's remained cold offshore. And then this began to abate in September in the top right panel. So that was the evolution of sea surface anomalies across 2007.
Then you look at 2008, the row below it. And it's cold everywhere. Those anomalies are -- so you see the kind of ocean that the fish entered in 2008, which ultimately led to the good returns in 2010, was markedly different than what they had experienced in 2007.
Q All right. Do any of the conditions that you've reviewed with us today indicate a causation between those conditions and sockeye survival, Fraser River sockeye survival?
DR. McKINNELL: No.
Q What do they show us?
DR. McKINNELL: This is not -- what we understand is that there's a correlation between these conditions and what we ultimately see.
Q So would we require further work to understand it better, to get to that level of understanding causation?
DR. McKINNELL: Yeah.

Q Okay. And the last area you talked about, I'm going to go through this one fairly quickly if I can with you, the Gulf of Alaska, in the section which you describe as the Gulf of Alaska, I take it this is the open ocean off the coastline, is that right?
DR. McKINNELL: Yes.
Q Okay. And you talk about "Large-scale climate processes", yes, that are at work in the Gulf. Can you just kind of briefly describe what those are and whether there's been -- you described in your report positive and negative phases. So talk about what those are and whether there's been changes in recent years.
DR. McKINNELL: Okay. I think the -- when we consider the oceanography and climate of the Northeast Pacific Ocean, the dominant influence of physical processes is the seasonal cycle, the annual cycle of going from winter to spring through summer. Winter, there's very little food available. There is a very, very deep mixed layer down exceeding 100 metres, low productivity, the light levels are low, and then this changes in the spring, as you get the mixed layer shallows, and you get increased light and productivity. So that is -- the cause of that is well-known. It's the position of the sun with respect to the equator. So generally people, when they're looking at variability in these large scale processes, they remove that annual effect because they know what causes that annual effect and they look for deviations from the -- from the seasonal means.
The next largest common large scale climate process in the North Pacific is associated with the atmospheric forcing through the -- through storms that come through in the winter, they mix up, so they have ability to mix the ocean deeply, which brings up more nutrients. So this, if you look at the time series of climate variability over the 20th Century, one of the things that's been discovered is that there are abrupt shifts in certain years from one phase to another. And 1976/'77 there was in fact a general warming of the Northeast Pacific, and these appear in many of the measurements that one might make of the surface ocean properties.
So you have a physical system in the North

Pacific that is kind of bimodal, by bimodal I mean it takes one of two states, and this is the -- this has an influence on our costal ocean. It has an influence over the broad Gulf of Alaska, and so I'll just move on now. So that's one of the major influences is this ability of the climate system to kind of shift from one state to another.
Q Is this when we've heard of regime shifts interfering, is that what you're talking about?
DR. McKINNELL: Yeah, this would -- yes. And you see it in both the oceanography and in the atmosphere, because they're a coupled system. The other major influence in the Northeast Pacific of interest to Fraser sockeye is probably the El Niño phenomena, which is a tropical climate system that has extra tropical influences. You know, in El Niño years we tend to get warmer winters, we get sea surface height elevations along the coast, which are caused by enhanced storm activity in the Gulf of Alaska. So those are probably -- the annual regime shifts and the El Niño are the three dominant large-scale forcings in the Pacific.
Q All right. And were there any significant temperature shifts as a result of any of these in 2007 or '08 that may have affected Fraser River sockeye?
DR. McKINNELL: Well, certainly the winter of 2006 and 2007 there was a remarkable climate phenomena that hit the coast of British Columbia north of about -- starting at Johnston Strait north. It left record snow packs in the -- whether or not it's directly tied to the El Niño in the winter of '06/'07 is not -- but ultimately what happened was some of the most extreme snow packs recorded in British Columbia occurred that winter, which was the year before smolts of our interest went to sea. And this led to that -- this incredible snow pack led to the freshwater, the freshening that we saw along the coastal ocean all the way from Queen Charlotte Strait to Southeast Alaska.
Q I'm going to just move along to the 2009 decline, the question that you were asked. What approach did you take when answering the question of whether there was a marine answer, I guess, to the question of the 2009 decline.
DR. McKINNELL: I mean, the approach we took in answering that question was perhaps not very

satisfactory, in that it's -- our assessment of the marine conditions through the life history of the smolts from 2007 to 2009 was that it was certainly possible that the extremes we observed in the Queen Charlotte Strait region and Queen Charlotte Sound, and even into -- there were even expressions of this in Southeast Alaska, could have led -- I mean, they're consistent with the idea of poor survival of sockeye. And they in fact may even have started in Georgia Strait where the -- you know, there was a footprint of this larger scale effect going on.
Q Did you -- you've talked already about the number of extremes that you saw in various areas in 2007. Are those extremes relevant to the analysis of the cause of low returns in 209?
DR. McKINNELL: I think one of the things that I have to do at this point is point out that it's not just the low returns in 2009 that have to be satisfied. There are a collection of observations that go along with this that also have to be explained. And in that same year we had double the average returns of sockeye to the Columbia River. We had better than expected returns of sockeye to Barkley Sound. We had very low returns of the one-year-old smolts from most populations that entered the Strait of Georgia, and that's the point you've raised about the 2009. But we had record high returns from sockeye that were in the Strait of Georgia in that same summer to Harrison River. And in fact I think the two-year-old smolts from Chilko Lake survivals were not -- measured at Chilko Lake were not affected as the one-year-old smolts. And we have Dr. Welch's observation of typically, typical survival of his acoustically-tagged Cultus Lake sockeye through the Georgia Strait in 2007. So what one needs to do is develop a model that somehow satisfies all of these concurrent observations.
Q Okay.
DR. McKINNELL: And certainly placing the mortality of this brood year, of the 2007 age-one smolts in Queen Charlotte Strait/Queen Charlotte Sound, has the possibility to satisfy all of these observations. Because the age-one smolts from -- and two-year-old smolts from the Fraser River must, you know, that's just their nature, is they

generally swim through Johnston Strait and Queen Charlotte Strait and Queen Charlotte Sound.
Q But they would also go through the Strait of Georgia, so why would you eliminate that?
DR. McKINNELL: Ah, the only reason I would -- I mean, I'm not eliminating it. I just would not put so much emphasis on it as the site, simply because of what I've explained before, that I was looking for extremes in physics and potentially in chemistry that would -- and where those occurred.
Q I just want to try and wrap up a few questions here. In your report in the preliminary section, your "Executive Summary" section you say that the extreme hydrographic and wind events in Queen Charlotte Strait and Sound did not have the same extremes in the Strait of Georgia, but that's contradicted in the Thomson report. Do you have any comment on that?
DR. McKINNELL: I guess -- I didn't study Dr. Thomson's report in detail, but in general his report was restricted to a small subset of the total amount of data that are available.
Q Mm-hmm. So you looked at more data, is what you're saying?
DR. McKINNELL: Yes. Yeah.
Q Okay.
DR. McKINNELL: You know, part of the analysis that we did, at least looking at the surface properties, was that the Nanoose hydrographic station which Dr. Thomson spent some time analyzing, is least similar to the lighthouse stations around the Strait of Georgia in June, which is the time when many of the Fraser sockeye are migrating through the region. And so the question then becomes how representative is any finding from the Nanoose station of general conditions in the Strait of Georgia.
Q Dr. Beamish also in his work in one of the other reports, that I haven't identified yet on the record but we will go to this afternoon, he looked at the condition of Fraser River sockeye and a number of other species in the Strait of Georgia in 2007 and noticed that there were similarities in condition across species, but you seem to discount that analysis. Why is that?
DR. McKINNELL: In part Dr. Beamish's report at times includes some of the fish and at times excludes

some of the fish, and in most of the plots that show time series, there's no indication of how uncertain the values are. It's typical to report, say, if you want to make a case that some year is different from some other year, it's very typical to include standard confidence intervals on your estimates of the mean value. The point I'm making here is that sample size matters and inherent variability matters. If you take a sample of 60 fish and you take a sample of 2,000 fish, chances are you will have a better understanding of the true meaning from a sample of 2,000 fish than you will from a sample of 60 fish.

And the other problem I had was that some of the statistics that are reported in Dr. Beamish's paper, pool, for instance, in reporting mean size or mean length, they pool two different age classes. And, for instance, the under-yearlings and the age-one smolts are just pooled, but the relative proportions of those will affect the mean value that you see. And it wasn't possible to distinguish very clearly what -- how much the pooling of these values was contributing to the mean. You know, the fact that you had one age that's a small fish and one age that's a large fish, how much that influenced them compared to the growth that they'd achieved to get to that stage.

THE COMMISSIONER: Okay, thank you. We'll take the noon break.

(PROCEEDINGS ADJOURNED FOR NOON RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: Order. The hearing is now resumed.
MS. BAKER: Thank you.

EXAMINATION IN CHIEF BY MS. BAKER, continuing:

Q I'd like to just complete my questions for Dr. McKinnell, with a last question. Do you have any views on whether the 2010 return was influenced by either an El Niño or La Niña event during their marine life phase?
DR. McKINNELL: In a section of our report, we described how the abundance of the 2010 return, the high return, was evident in the test fisheries

the year before, in 2009. There was the younger fish, the jacks, as we've called them, that return after only one year, were seen in higher abundance than has appeared for a very long time, and we interpret this to be an indication that the high abundance of the return in 2010 was established at least a year earlier than the time when the 2010 return occurred, in which case the '09 - the 2009-2010 El Niño would not have a marked effect on -- if, indeed, the jack abundance indicator in the test fishery was indicating the returns to come, which it seemed to be.
Q Thank you. I'd like to move, now, to Dr. Welch. Dr. Welch, you appeared in October before the Commission, and you gave us a presentation, at that time, on your post work, and you provided us with a presentation that involved a PowerPoint, and we looked at a couple pages of that this morning, or a page of that this morning, and I don't want to review that material again, but what I do want to ask you if you have done since that time, you've published a paper that provides that analysis or some commentary on that analysis and some additional information, and that is at Tab 21 of the Commission's list of documents, if I could just have that put up. That's the paper that you've now published?
DR. WELCH: That's correct.
MS. BAKER: Okay. Could I have that marked, please?
THE REGISTRAR: This exhibit will be 1292.

EXHIBIT 1292: Welch et al, In Situ Measurement of Coastal Ocean Movements and Survival of Juvenile Pacific Salmon, 2011 [BC Post Study, PNAS]

MS. BAKER: Thank you.
Q So based on the work as outlined in this article and generally, have you been able to draw any conclusions about the relevance of Cultus hatchery fish, which is what you were tagging, to represent Fraser sockeye, all stocks, and their migration routes and timing?
DR. WELCH: Well, we can't -- from this paper, we can't talk about the other stocks of Fraser sockeye, because we don't -- we've only so far analyzed -- reported, in this paper, Cultus Lake sockeye, but

what I think counsel's referring to is figure 5, which can be brought up. One of the large questions about the telemetry system is whether it's affecting the survival of the fish with larger fish surviving better either because bigger fish survive better or because the tag is reducing the survival of small fish. And the top row shows that for the four species that we've looked at, which includes both Sakinaw sockeye and Cultus Lake sockeye, that the average size of the fish at release, in the second row, is no different than the average size of the fish at release of the fish that survived to make it out of the Strait of Georgia or to the north end of Vancouver Island, which includes the sockeye.

And then the other graphs that are within that simply show that for the four species that there was no change in other aspects of the size distribution, so larger fish were not surviving better relative to smaller. So that was one of the two key points in the paper.

And the other one was that survival out of the Strait of Georgia north to the north end of Johnstone Strait and Queen Charlotte Strait was, to my mind, high and stable across the four years that we looked at it. It was about 28 percent survival to the north end of Vancouver Island, but only two percent -- pardon me, one percent, or two fish, out of the 200 we released survived to come back and were detected coming back in over the array two years later.

Q What about the impacts of the tags, themselves, on the fish; did you draw any conclusions from that?

DR. WELCH: Well, as figure 5 shows, there was no difference between the size at release of all the fish, and then the grey bars in the top row of panels and the size of the fish that did survive to make it up to the north end of Vancouver Island, about 400 kilometres away, a month, month and a half after release. So what the data is suggesting is that surgery done properly does not affect the survival of the fish over the size range that we've tagged, which is down to 13 centimetres, a little larger than the wild smolts, which are 10 or 11.

Q And in your paper you also talk about total mortality versus a mortality rate, and I'd like

you to explain what those two terms refer to and why that's a distinction that you think is important.
DR. WELCH: Yes. In fisheries for about a century, the theory has been that there's a critical period early on in the life history, because the mortality rate is very high. The key point there is that the mortality rate is high, but it's a relatively short duration relative to the rest of the life history. So in the rest of the life history in this case, after the first month and a half after release, for Cultus Lake sockeye we're able to do a calculation that's seven-eighths of the total mortality after release at Cultus Lake occurred north of Vancouver Island.
Q Okay. In 2010 you actually tagged some Chilko smolts instead of Cultus Lake smolts; is that right?
DR. WELCH: That's correct. That was the work you're referring to with Dr. Scott Hinch of UBC and his team as well.
Q Okay. And can you just describe -- we have a slide that you've prepared that might be useful in answering the question as to what the results of that work have shown, and that slide is at Tab 20 of the Commission's list of documents.
DR. WELCH: Right. So what this graph shows, the colours of the symbols -- well, let me step through it. So from left to right it shows survival from release to the Lower Fraser River, the last detection sites we had in the Lower Fraser River -- pardon me, this graph is different from the ones that have been seen before. Chilko Lake sockeye, in 2010, is the yellow dot on the right-hand side. This is new data that hasn't been published as yet. And to prepare this, we've taken the survival from -- essentially from Mission in each year, because Cultus Lake sockeye are released in Cultus Lake; Chilko is almost 500 kilometres up the river, and we've taken the survival from Mission, the first receiver in the lower river each year, to the last receiver in the river, a distance of about 60 kilometres, and we've compared the survival for that section in the Lower Fraser River.
So survival is very high in all years. The Cultus Lake data for the prior four years, in

fact, we showed there was actually quite -- or found there was quite high mortality in some years, 50 -- only 50 or 20 percent of the fish were surviving to the Lower Fraser River from release. What this figure shows is that it's isolated to the period immediately after release from the outlet of Cultus Lake to the Fraser main stem, just downstream from the Sweltzer Creek, the conduit from the lake to the Fraser River.

So overall, the issue is that in the Lower Fraser River the survival is high for all of the stocks, or all of the years, and then in the northern Strait of Georgia, which is from the Fraser River mouth to the north end of Texada Island, Comox to Powell River, survival is high and fairly stable. And then the surprise for us in 2010 is the survival from the north end of Texada Island to near the exit of Queen Charlotte Strait, survival was only about a third to a quarter in 2010 for these smolts.

The Chilko smolts were wild, two-year-old smolts. The Cultus Lake smolts, in prior years, were hatchery smolts.

Q And does the fact that these smolts were -- the Chilko smolts were two-year-olds make any -- should we -- how should we interpret that, I guess, as against the bulk of the fish which are one-year-old smolts?

DR. WELCH: Well, Dr. Irvine, of DFO, and Scott Aikenhead, have an unpublished paper showing that survival, marine -- sorry, survival of -- first, one-year-old Chilko smolts and two-year-old Chilko smolts, on average, is nearly identical, so one would infer from this that you would see something different for the one-year-old smolts, had we tagged them, but one-year-old smolts would require a revised version of the telemetry rate. It's now possible to do that, but the existing array can't handle those small, one-year-old smolts.

Q Sorry, just to make sure I understand, you're saying that if you had been able to tag one-year-old smolts you would have expected to see a difference in survival, as against the two-year-olds when they entered the ocean, or are you --

DR. WELCH: No, my personal view --

Q -- just -- sorry...

DR. WELCH: -- is we would expect to see the same

pattern, because the survival that Irvine and Aikenhead report from Chilko lake for one and two-year-old wild smolts is, on average, the same.
Q All right. So is it your view that the survival rates that you see on your tagged fish, then, is reasonably representative of what you would expect for the one-year-old wild smolts?
DR. WELCH: That's my conjecture. What we've done with the proceedings in the National Academy of Sciences paper that just came out was show that over the size range we can tag with the existing technology that we're not seeing these differences in survival with size that previously the theory was that they would be there; in practice, we haven't seen it when we've looked for it.
MS. BAKER: Thank you. I'd like this slide, please, marked as the next exhibit.
THE REGISTRAR: Exhibit 1293.

EXHIBIT 1293: Fraser Sockeye Smolt Survival Estimates, Welch et al

MS. BAKER:
Q All right, so this work that you've just described showed the Lower Fraser, Mission to the mouth of the Fraser, as having reasonably good survival. What do you know about survival from the lake to Mission?
DR. WELCH: So as I said, in Cultus Lake, most of the mortality in the Fraser River that we measured occurred between release and essentially the exit from Sweltzer Creek into the main stem of the Fraser. It's a small, clear river and it looks like a lot of things do eat sockeye within that, so there's predators there. And then the Fraser main stem was not the location where the mortality was observed.
In 2010, we observed something very similar up in Chilko Lake. The first section of the migration, a clear water river running from Chilko Lake, we had much higher mortality there. And then some differences in the behaviour of the fish. And then once they reached the main Fraser River, mortality rates dropped, the survival was high down the Mission, and the behaviour also changed, to suggest that they were not trying to avoid predators at that point.

Q You've heard, today, and I think you're aware of some works that have been published, relating the time spent of Fraser sockeye in the Strait of Georgia to their survival, or their returns two years later. Do you have any views on the importance of the Strait of Georgia in relation to returns of adult sockeye, Fraser River sockeye?

DR. WELCH: Yes. So the Strait of Georgia is one of the ecosystems that these animals move through in sequence, and it's certainly relevant and important. I wouldn't characterize it as the determining location where adult returns are determined in majority. It's one of the sections.

If we look at the rates of movement of the fish, our acoustically tagged smolts are moving about a body length a second, which is typically what's expected for fish. The wild fish, Dr. Trudel has caught the untagged wild fish up in Hecate Strait from the Fraser River. Those smaller wild fish are also moving at about a body length a second. So take that as just under 10 kilometres a day that the wild fish would be migrating. So to get to the north end of -- from the Fraser River mouth to get to the north end of the Strait of Georgia, 150 kilometres, so about 15, 20 days for the average smolt to clear through the Strait of Georgia, and then something similar to get up to the Queen Charlotte Straits sub-array that we have.

Q Okay. And what about the influence of conditions in the Queen Charlotte Sound and Queen Charlotte Strait areas?

DR. WELCH: Well, unfortunately, we don't have the array up in that area to measure the -- or census the number of smolts that enter the Queen Charlotte Sound and then exit to the north. We have had, in past years, a sub-array up in Alaska, but it has not detected the Cultus Lake or the Chilko smolts up there. But it's almost 2,000 kilometres from the -- 1,500 kilometres from the Fraser River.

Q Okay. In one of the reports, which we'll deal with, with Dr. Beamish, it's a paper identified by the author Preikshot, and it's -- just to identify it for the Commissioner, but we'll come to it later, it's Tab 15 in the Commission's list, and it talks about the residence time of juvenile

Fraser River sockeye salmon. And in this document, they estimate 35 days for residence time in the Strait of Georgia. Would you agree with that?

DR. WELCH: Well, I'd say it was an overestimate. The estimate was -- I've reviewed the document, it's based on the time of arrival at the -- an estimated time of arrival at the Lower Fraser River, the last one percent of the migrating smolts, and then the estimated time of arrival of the last one percent of the migrating smolts at the north end of the Strait of Georgia. And that tends to spread out the distribution, because we know that sockeye smolts, some of them go into the inlets, such as Howe Sound, so their average speed drops. But even if we take that as the estimate, that would be about 35 days. All of the acoustic telemetry work is indicating four to seven days for the smolts to get from release at the lake down to the mouth of the Fraser River, so even if I would -- my calculation would be, rather than the 35 days that Preikshot, et al would suggest the average would be closer to 15 days, couple of weeks.

So since the peak of the run is leaving the Cultus or Chilko Lake at the end of April, that puts them out of the Strait of Georgia, the majority out of the Strait of Georgia by the middle of June.

Q And you may have already explained this, but when you talk about the telemetry work you did, you were dealing with larger hatchery fish and larger two-year-old smolts. Does that affect the timing or not?

DR. WELCH: Well, as I indicated, they seemed to be moving at the same speed, in terms of physical size and in terms of body lengths per second, about one body length per second, and Dr. Trudel has data from Hecate Strait for wild one-year-old smolts that also indicating that they're moving about a body length a second, or a little more. So his estimate also, which is a paper in the 2010 DFO, called Ocean Distribution of Two Depressed Sockeye Salmon Stocks, he obtains, for untagged wild smolts, about 1.1 to 1.4 body lengths per second, similar to what we do for the larger, acoustically-tagged smolts.

So scaled for their size, the fish are swimming at the same speed, about just over a body length a second.
Q I just want to make sure we've got the right documents here, because we've got a new production that seems to be the same.
You'd mentioned Marc Trudel. He's a scientist with the Department of Fisheries and Oceans; is that right?
DR. WELCH: Correct.
Q And you're familiar with some of the trawl surveys that he's done in Queen Charlotte Sound and Hecate Strait?
DR. WELCH: Yes.
Q Okay. I want to show you some documents that have been produced by him that I think you've seen already. Tab 39 is a PowerPoint. We do have it in black and white in another tab, but I think the colour might be more helpful. And I probably should have talked to Mr. Lunn about this, because he's going to struggle to find it, because the page aren't numbered. I would say it's about two-thirds of the way through this document, so maybe at about page 40.
DR. WELCH: It's before that, or it should be.
Q All right. So try going around 35. There.
DR. WELCH: There.
Q There we go. Okay. So I've got those -- these. And also in Canada's documents, at Tab 9, there's one for 2010. Okay. All right, so let's start with -- first identify what these are, and then we can go through them. If you could identify what these graphs are showing?
DR. WELCH: Oh, sorry. All right, so this is Dr. Trudel's data for, essentially, Queen Charlotte sound, Hecate Strait and Southeast Alaska. So from the bottom of the graph to the top it goes west coast Vancouver Island samples, Queen Charlotte Sound samples, west coast of Queen Charlotte Islands and Hecate Strait, and then Southeast Alaska is the top. And then within each of the three main sections he's divided it into outer -- farther from the mainland and inner route samples.
So the essential point that I'd like to point out here is that the bright green shows the Fraser River sockeye salmon. This is all stocks of

sockeye salmon together. And essentially what Dr. Trudel's data shows, in 2007 sampling during June and July, that about 30 to 40 percent of the Fraser sockeye off the Queen Charlotte Islands/Hecate Strait are of Fraser River origin.

Now, in 2008, which is the central section, there's certainly a larger section of the pie that's bright green; it's around 60 percent.

The point that I'd like to make here, though, is that we're expecting a 20 to one return of adult sockeye back in 2009 versus 2010, about 1.5 million versus 30 million. So we're not seeing, in my view, the very large difference in the proportion of Fraser sockeye in 2008 that you would expect. You would expect, if the abundance of the other stocks was consistent with it having been set by the Queen Charlotte island/Hecate Strait area, you'd be expecting that green pie, in 2008, to be about 90 percent of the total sockeye that was caught. So it's certainly larger in 2008 smolt out-migrating year than in 2007, but it's nowhere near large enough to fully explain the massive difference in adult returns between 2009 and 2010.

So there's evidence that by Hecate Strait there was some difference in abundance, but not nearly enough to explain the big difference in returns.

And then in June/July 2009, the pie is even bigger for the Central Coast area. So I would argue that Dr. Trudel's survey is in about the right place at the right time, given the speed of movement of the smolts, but it's not showing that the large differences in adult sockeye return had been set by that time.

Q Thank you. I think I'd like this PowerPoint, or document, marked as the next exhibit. And perhaps for the record we can identify that this page that you're looking at is page 34.

THE REGISTRAR: Exhibit 1294.

EXHIBIT 1294: Beacham et al, Ocean Conditions Inside and Outside the Strait of Georgia are Important Contributors to the Fraser Sockeye Situation, April 2011

MS. BAKER:
Q I did ask you if you were familiar with the one at Tab 9 in Canada's list of documents. This is just an updated survey for the 2010 year. I don't know if this adds anything. The sample sizes look fairly small in this one, so I'm not sure if it's helpful or not.
DR. WELCH: Sorry, is this the 2010 or 2009?
Q I understood this to be the 2010.
DR. WELCH: Okay. It looks similar to the 2009 results, which is that significant fractions of the sockeye that are out there from Fraser River populations. But as you say, particularly in 2010, these are, for reasons I don't know, the sample size of sockeye is much smaller in this year. The total -- the "n equals" number under each of the pie says -- indicates the number of fish that they had to do DNA analysis on.
MS. BAKER: Okay. I'll have that marked, please.
THE REGISTRAR: That would be 1295.

EXHIBIT 1295: Trudel, Interannual Variation in Juvenile Sockeye Salmon Stock Composition, Figures for 2010

DR. WELCH: But to put that in perspective, in 2009, and in this case 2010, these are years that we don't know what the adult returns would be like. But this would suggest that we'd have even larger sockeye returns to the Fraser relative to these other stocks, relative to 2008, because the section of the pie chart that's green, the Fraser River, is even larger. We won't know for one or two years, until the adults come back, whether that's true or not.
MS. BAKER:
Q But before you draw that conclusion, would you not want to have a look at the sample size which, as you indicate in this, only 12 fish had DNA sampling done?
DR. WELCH: Well, I've indicated that the sample size here is smaller. The thing that I'd like to see followed up, which I don't have available here, is what's the relative abundance of the spawning escapements for these others stocks that make up the mix each year? We're assuming that it's approximately the same. We're not expecting a

radical change in the number of spawners that return, say, to the west coast of Vancouver Island, and technically we're assuming that it's remaining absolutely stable when I say that in 2008 we should have seen Fraser sockeye making up 90 percent of the Hecate Strait DNA stock composition. We're not seeing that. It's a slim possibility that the escapements in other areas had dropped a lot that produced those fish, but it's not very likely.

Q I'd like to move to another topic, now, talking about distribution of salmon in the Gulf of Alaska. And you touched on this earlier. You indicated that your tagging -- your Cultus fish that you had tagged weren't detected in the receivers in Alaska. Does that tell you anything about the coastal or open ocean distribution or timing of Cultus?

DR. WELCH: Yes. it's unlikely that they're moving off the shelf, as Dr. McKinnell had indicated, that's a possibility. We have an unpublished paper from the trawl survey work I did before I left DFO, showing that in October through to December that essentially all species of smolts or post-smolts were staying on the shelf much later than people had anticipated, and we're still migrating north out of the area.

So that leaves two possibilities. One, is that the array up in Alaska didn't detect them, which is a possibility, because in the pilot phase we essentially only could run it halfway across the full width of the Continental Shelf. So if the smolts had gone farther offshore in deeper water than 200 metres, we would have missed them. Or the other possibility is that they've taken up residence somewhere south of the Alaska sub-array and were over wintering there.

Q Do you think it's important to understand the distribution of sockeye in the Gulf of Alaska?

DR. WELCH: On the Continental Shelf certainly, because we need to understand what area is causing these dramatic -- first off, the dramatic year to year variation in survival, but also, perhaps even more important, is this 20-year-long decline in survival. If we really need to know what's happening, we need to pinpoint the areas where that problem is occurring.

Q And is it expected or understood whether Fraser River sockeye randomly distribute in the Gulf of Alaska, or does each stock go to a different place, or do we have any information on that?
DR. WELCH: I think it's clear from the data that's available that they're not randomly distributed. We don't fully understand what it is, but there are multiple sources of evidence that suggest different stocks have, at least to some degree, different areas of distribution within the Gulf of Alaska.
Q And in the Technical Report 4, Dr. McKinnell talks about a thermal limits issue, which, I think, is reflecting work that you've done. Can you explain what that is?
DR. WELCH: We collected the data from the 1950s to about 1994-95, from Japanese, American, and Canadian high seas research cruises, and then looked at the distribution of sockeye salmon across the north Pacific, and in that paper what we showed was that there was a sharp southern limit to the distribution of sockeye that was related to temperature. So basically within about a degree Celsius in most areas of the north Pacific, sockeye salmon abundance for the immature fish dropped by an order of magnitude, a factor of 10 or more, so a very sharp southern or warmer thermal limit to the distribution.
Q All right. And why is that important?
DR. WELCH: It's important because the global warming models are predicting large-scale changes in the thermal -- or the temperatures of the north Pacific, and if the sockeye maintain these thermal limits and migrate or move to avoid what's predicted to be a warming ocean by -- with the most recent crop of global warming models, it's suggesting that their thermal habitat for at least parts of the year would be only found in the Bering sea, and potentially could be excluding -- well, certainly excluding all of the Gulf of Alaska.
Q And to understand the distribution of the Gulf -- excuse me, the distribution of Fraser sockeye in the gulf of Alaska, are there research methods that you know about that would be useful in doing that kind of work?
DR. WELCH: Well, our work was an observational study

based on the capture of fish from various types of fishing gears across the north Pacific. It's not an experimental test. I would very much like to see it tested -- the theory tested. We've put forward the observation. That could be done with what's called archival tags, for example, which would establish the movements of fish, of sockeye salmon in this case, and establish whether they do or do not cross these apparent thermal limits or boundaries.

There are suggestions that the animals could go deep into the deep ocean, which has little light and little food, and something that, so far as we know, don't do now, but that would be one method to escape the warming surface waters.

So a direct experimental test that refutes or supports the observational data we have would be a very interesting and useful method of looking at that. More broadly, from a public policy perspective, it's important, because if the climate change come to pass, as we predict, or as the models are suggesting, there are potentially very large losses and further losses in productivity of sockeye salmon, and we'd want to understand whether that aspect of the life history is causing them, or is it something else.

Q The Commissioner asked Dr. McKinnell about further freshwater lake assessment needs, restriction needs, and talked about counting at the lakes, and Dr. McKinnell talked a little bit about counting fish at the mouth of the river, so I have a couple questions for you there.

The first one is, do we, in your view, do we need to add additional freshwater counting or assessment; and the second question is, just to pick up on what Dr. McKinnell was talking about, counting at the mouth of the river, is there any ways to do that effectively, now?

DR. WELCH: Well, my personal opinion is that most of the problems are happening in the marine environment as opposed to freshwater, but sampling at the mouth of the river to get, for example, the total abundance of sockeye coming down each year would be useful as a way to keep on the table or take off the table the issue that changes in freshwater are or are not contributing as a significant driver what's happening, and that

could be done simply -- I believe there's still a sampling program at Mission that's been going on that catches the number of sockeye smolts going down the river each year. That could be supplemented, for example, by a DNA analysis of the individual fish to get an index of total sockeye out-migrant abundance, presumably at Mission, since that's where the current sampling is, and then supplemented by DNA so it could break down what the relevant stocks are.
Q Thank you. I have a couple of questions, both for Dr. Welch and Dr. McKinnell, relating to research needs and priorities, so I'm going to hold those to the end, because I'd like to move to Dr. Beamish now.
First of all, I'd like to begin with the four reports that you were either a primary or secondary author on, and I'll just identify them. The first one is at -- follows your primary one, and I think that's at Tab 13 of the Commission's documents. You're the lead author on this, and it's titled, Evidence of a Synchronous Failure in Juvenile Pacific Salmon and Herring Production in the Strait of Georgia in the Spring of 2007; is that right?
DR. BEAMISH: Yes.
Q All right. And I think as we're very short on time today, so I'm just going to identify very, very quickly, where the CVs are for the other authors of this report. They're at Tabs 40 and 41 of Canada's documents. So that is one of the authors, Neville, and then Tab 41 is Sweeting; that's correct, those are the CVs of the other co-authors?
DR. BEAMISH: Yes, they are.
MS. BAKER: I'd like those both marked, please.
THE REGISTRAR: Exhibit Number 1296.

EXHIBIT 1296: *Curriculum Vitae* of Chrys-Ellen M. Neville

MS. BAKER: Is that for the Neville c.v.?
THE REGISTRAR: Yes. And the next exhibit will be 1297.

EXHIBIT 1297: *Curriculum Vitae* of Ruston Matthew Sweeting

MS. BAKER:
Q And then that primary document is supported by three other papers which address a number of other issues, so the first one I want to go is one called -- at Tab 14 of the Commission's documents, and it's called, Anomalous Ocean Conditions -- or it addresses anomalous ocean conditions in coastal regions. And the lead author on this is Dr. Thomson?
DR. BEAMISH: Yes.
Q And the other authors listed, I just should identify their CVs for the record as well. They're in Canada's documents. First of all, Thomson's c.v. is in Tab 46. If that could be marked, please, once it's identified. Is that his c.v.?
DR. BEAMISH: Yeah.
THE REGISTRAR: Exhibit Number 1298.

EXHIBIT 1298: *Curriculum Vitae* of Richard E. Thomson

MS. BAKER: Thank you.
Q Terry Beacham is the next author, at Tab 42 of Canada's documents; is that correct?
DR. BEAMISH: Yes. Yeah.
MS. BAKER: Okay, the next exhibit, please?
THE REGISTRAR: 1299.

EXHIBIT 1299: *Curriculum Vitae* of Terry Dale Beacham

MS. BAKER: Thank you.
Q Mark Trudel, Tab 44 of Canada's documents?
DR. BEAMISH: Yes.
Q We'll get it up on the screen, first.
DR. BEAMISH: Here it comes, yes.
MS. BAKER: Okay. If that could be marked, please.
THE REGISTRAR: Exhibit Number 1300.

EXHIBIT 1300: *Curriculum Vitae* of Marc Trudel

MS. BAKER:
Q Tab 45 is Whitefield's c.v., yes?
DR. BEAMISH: Yes.
MS. BAKER: If that could be marked, please.

THE REGISTRAR: 1301.

EXHIBIT 1301: *Curriculum Vitae* of Paul Whitefield

MS. BAKER:
Q And then, lastly, Tab 47 is the Hourston c.v., if that could be marked once it's --
DR. BEAMISH: Yes.
Q -- identified. Thank you.
THE REGISTRAR: 1302.

EXHIBIT 1302: *Curriculum Vitae* of Roy A.S. Hourston

MS. BAKER: Okay, I'd like to have -- I'll mark Tab 14, please, as the next exhibit. And then I'll come back. I forgot to mark your primary document, but I'll do that when we come to it. So if I could have this Anomalous Ocean Conditions document marked?
THE REGISTRAR: 1303.

EXHIBIT 1303: Thomson, et al, Anomalous Ocean Conditions May Explain the Recent Extreme Variability in FRSS Production, March 2011

MS. BAKER: Thank you.
Q The next report deals with residence time of juvenile sockeye in the Strait of Georgia, and we've referred to that, today, as the Preikshot report, and that's at Tab 15 of the Commission's document list?
DR. BEAMISH: Yes.
Q All right. And you're an author along with a number of other authors whose CVs we've already marked. The only one we haven't marked, yet, is Dr. Preikshot. That's at Tab 43 of Canada's list.
DR. BEAMISH: Yeah.
MS. BAKER: If they could be marked once identified. That's it.
THE REGISTRAR: 1304.

EXHIBIT 1304: *Curriculum Vitae* of David B. Preikshot

MS. BAKER: And the report, itself, I'd like marked, please.
THE REGISTRAR: 1305.

EXHIBIT 1305: Preikshot, et al, The Residence Time of Juvenile FRSS in the Strait of Georgia, undated

MS. BAKER: Thank you. And the final one dealt with late ocean entry life history of Harrison River sockeye and South Thompson Chinook sockeye, and that's at Tab 16 of the Commission's list.
Q Correct?
DR. BEAMISH: Yes.
Q Thank you. And the c.v. for the only author we haven't dealt with yet, which is Lange, is at Tab 23, I think, in Canada's list. Okay, if I could have the c.v. marked. First of all, is that Krista Lange's c.v.?
DR. BEAMISH: Yes.
MS. BAKER: Thank you. Mark it, please.
THE REGISTRAR: 1306.

EXHIBIT 1306: *Curriculum Vitae* of Krista Lange

MS. BAKER: Okay. And the report, itself, we'll mark as the next exhibit.
THE REGISTRAR: 1307.

EXHIBIT 1307: Beamish, et al, A Late Ocean Entry Life History Type Has Improved Survival For Sockeye and Chinook Salmon in Recent Years in the Strait of Georgia, undated

MS. BAKER: Thank you.
Q All right, now, these four reports, as I understand it, extend what's been described as the critical size/critical period hypothesis that you first composited in 2001; is that right?
DR. BEAMISH: It's a component of these reports yes.
Q Okay. Can you explain what that hypothesis is?
DR. BEAMISH: Well, the concept -- excuse me, I'll just fix my voice here. I will have a few problems with my voice, okay, but I think I can fix it with water.
So the critical size - can everyone hear me -

the critical size/critical period hypothesis is a concept that a colleague and I, named Dr. Connie Menken, and I wrote about maybe 10 or more years ago, and it's basically an extension of the interpretation that many scientists have had for a long period of time, that the early marine period is a critical or very important time for the survival of all species of salmon. And what we proposed in that concept was that -- and again, some of this, of course, is not new. But the concept was that juvenile salmon, in fact, juvenile fish in general, grow very quickly and literally millions, or hundreds of millions of juveniles will start off after they hatch and the mortality is very large in that early marine period.

And so the concept of the critical size/critical period hypothesis is that fish that grow really quickly are the ones that, usually around the end of June, although that's pure speculation, will begin to store their energy more than they use the energy from feeding and to grow, and so they begin to store energy as lipids and reduce the amount of energy that goes into growth.

What can happen, then, is that the fish that have grown quickly and have stored energy over the summer then survive much better during the more harsh periods for survival in that first marine winter. Of course, the first marine winter can be important, because if the growing conditions in the winter are also -- well, if they are favourable or unfavourable, it can influence what happened in that critical period.

So in general, then, what we're saying is that juvenile salmon enter the ocean and have to grow quickly. There's large mortalities in that first up to six week period, and the fish that grow the fastest are the ones that are the larger ones, store energy and continue to store energy through the summer and survive the harsher conditions when feeding is less available, and prey are less available in the winter.

And then I said that you can have the anomalies where you could have some very poor growth in that first marine period and then you might be compensated, to some extent, by maybe exceptional conditions during the winter. But

those conditions would, in general, be rare.
Q And the article that you're referring to is actually on Canada's list at Tab 3, I think, if we could just pull that up.
DR. BEAMISH: I'm sorry, just say that again.
Q The article that sets out that hypothesis --
DR. BEAMISH: That's one of the articles, yes.
MS. BAKER: Okay, I'll have that marked, please.
THE REGISTRAR: Exhibit 1308.

EXHIBIT 1308: Beamish, et al, A Critical Size and Period Hypothesis to Explain Natural Regulation of Salmon Abundance and the Linkage to Climate and Climate Change, 2001

MS. BAKER: All right. And I'd like to turn to the report that's titled, Evidence of a Synchronous Failure in Juvenile Pacific Salmon and Herring Production in the Strait of Georgia. First of all, I didn't mark this when we went over it the first time, so I should mark that now.
THE REGISTRAR: Exhibit 1309.

EXHIBIT 1309: Beamish, et al, Evidence of Synchronous Failure in Juvenile Pacific Salmon and Herring Production in the Strait of Georgia in Spring 2007, undated

MS. BAKER: Okay.
Q Can you just give us a very brief overview of this report, what the intention was?
DR. BEAMISH: Okay. It's going to be maybe a little longer than you might want, but this is really the essence of what the four papers are about. We've done a number of surveys in the Strait of Georgia since -- well, since the mid-90s, but we report them since 1998, and maybe, well, literally hundreds of trawl sets. And in the surface waters, in the surface 30 metres in the Strait of Georgia - I can't remember exactly - but around 1,800 sets that we've made over that period of time, almost 98 percent of the fish that we catch in the surface 30 metres are juvenile herring or juvenile salmon.
In 2007, the year that we're interested in, pink salmon from the Fraser, juvenile pink salmon, were rare. They spawn in the even-numbered years

- sorry - spawn in the odd-numbered years, and then the juveniles enter in even-numbered years. So 2007 being an odd-numbered year, you would not expect pink salmon from the Fraser to be in the Strait of Georgia.

So we then had juvenile fish that consisted of herring, correctly, I guess, Pacific herring, and then sockeye, chum, Chinook and Coho. And I've now mentioned that they represent about 98 percent, so virtually all of the juvenile fish in the surface 30 metres.

Now, all of those fish in 2007 ended up having poor growth or poor survival or both. And perhaps the most spectacular observation was with juvenile herring. Juvenile herring, of course, spawn early in the year, and then after the eggs hatch, the larval herring, of course, feed and grow. In September of the year, the herring assessment group does a survey, they use purse seines, and they've been looking at the relative abundance of juvenile herring to -- as an estimate of what would be recruited three years later, recruited into the fishery.

And in 2007, their survey estimates indicated that they had the lowest abundance of juvenile herring in their -- in the history. I think the survey went back to the early 1990s. In addition to that, as a -- or maybe I'll just follow-up on herring, let me finish that. So extremely poor survival of juvenile herring in the Strait of Georgia, in 2007, through to September. Now, we saw the same thing in our surveys.

Then, when the herring that were spawned in that year were recruited into the fishery in 2010, the commercial fishery, those recruits usually represent about 60 percent of the commercial catch. And in 2010, if I remember correctly, it was around six percent. It was the lowest recruitment ever recorded of a year class.

In addition, when we look at the stomach contents of the various species, Chinook salmon are the species that feeds most heavily on juvenile fish in the July period. And normally juvenile Chinook salmon feeding in the Strait of Georgia would feed on roughly 60 percent, 50 to 60 percent of their diet would be fish, and about 60 percent of that would be Pacific herring.

In 2007, the juvenile Chinook salmon had a composition of less than 10 percent of fish in their diet, and none of that was herring, and that's in July. And that's very good evidence that the juvenile herring, most of them had not survived through to July 2007.

And then we then follow that up with the other four species, and we know that juvenile sockeye did not survive very well, and there is this issue of exactly where the mortality occurred. I guess I should have mentioned, when I talked about the critical size/critical period hypothesis, that the actual mortality does not have to have occurred in the same location that the poor growth occurred, and mortality can occur later. I guess by inferring that it could occur in the winter, that would also indicate that that's possible.

But it's quite important to recognize that when fish die they don't necessarily have to die exactly on the spot where the problems that eventually caused the mortality occurred.

Okay, so looking, then, at -- so recognizing that sockeye salmon survive very poorly, and I think there's no question about that.

Now, in our surveys in late June through to mid-July, their catches of juvenile sockeye are small. There's no question about that. And they're also, I think it's fair to say they represent the, as has been described, the tail end of the migration. But it's also very important to know that in the various publications that we've produced, that that tail end of the migration, when we do the DNA sampling, the stock composition is entirely consistent with the expected stock composition of all of the populations that compose the total run for that year. In other words, the tail end of the distribution we are sampling the population, we are sampling all of the stocks, and we've done that over three years, and the DNA is consistent. So the tail end, we think, is representative of the overall population composition.

We know that the -- now, the sample sizes are small, and that has been pointed out already, and we accept that, but we know from the small sample sizes, both in the Strait of Georgia and in Queen

Charlotte Sound, where it's important to actually look at the sockeye in Queen Charlotte Sound, rather than Hecate Strait, a rather unusual situation, but in Queen Charlotte Sound in that year, the juvenile sockeye, in June and in July, were small and generally in poor condition. So the fish that we were able to sample, both in Dr. Trudel's survey and in ours, were, in our opinion, not in really good condition.

We then switch over to Chinook and Coho, and Chinook and Coho samples in July, and we show this in the paper, that the sizes, both in terms of lengths and weight, were very small, and when we make a calculation on condition, the condition also was the lowest in the time series.

The Chinook that went to sea in 2007, not all of them will be back. They come back as both, well, mostly fours and fives, mostly. And so we still have to wait to get the final returns for Chinook salmon. The Coho that went to sea in 2007, returned in 2008. The returns of Coho in recent years, not so much in the last year, but in recent years, has been very poor, and 2007 was the poorest in the last four or five years, but, you know, that's a little bit of an exaggeration, because the returns are so poor anyhow, having a poor return in a very poor period only indicates that the overall survival was not -- well, was exceptionally bad. So poor growth, poor condition, and poor survival the next year.

The final species that was in the surface waters in 2007, was chum salmon. The catches of juvenile chum salmon in 2007 were, I think, the lowest in the time series. The condition was a little bit better, but the abundance of juvenile chum was extremely low.

Those chum, most of those chum, or many of those chum, returned in 2010, and in the paper we point out that around B.C. it was publicized in a local paper that the returns to Goldstream were extremely poor. And subsequently, we noticed that the returns to other streams or chum in other streams had also been extremely poor. The data are a little more than preliminary now, and I don't think that people question the data that are available, so I think it's fair to conclude that the chum salmon that went to sea in 2007 had extremely poor survival.

So in summary, then, what we saw was all of the species in the surface waters, in the Strait of Georgia in 2007, had extremely poor growth or survival, and I've been in this business about 40 years, and I don't know of a situation of such a synchronous failure in year-class strength anywhere. I've given this talk a couple times at workshops and conferences, and there has been a suggestion from the audience about something that might be similar, but I still say that, again, certainly in my experience I hadn't seen anything as remarkable as this.

So my conclusion is that this is absolutely outstanding, which was the reason that we wrote this paper. In other words, in my opinion, there was absolutely no doubt that we saw a very anomalous situation in terms of the factors that effect the overall brood year strength of salmon and, in this case, the year-class strength of herring.

Now, I'm sorry that too a little longer, but...

Q Well, you've kind of eliminated a lot of questions I had for you, so probably, on a balance, it probably works out just fine.

Just to pick up on a couple things, you mentioned, though, you said the Coho go out and -- so the 2007 Coho came back in 2008. What did you see with respect to the Coho that went out in 2008 and came back in 2009? Or have I got that wrong; 2007 they were in the Strait of Georgia and they came back in 2009, or 2008?

DR. BEAMISH: 2007 came back in 2008.

Q Okay. So what did you see with respect to the next couple of years, so 2008 coming back in 2009?

DR. BEAMISH: 2008 coming back in 2009, now, the marine survival improved, okay? I can't remember exactly what it was, and it might be in one of the papers, but it went from -- it increased. And I'm predicting three percent survival for this year, in case anyone wants to check.

Q One of the things you say in your report is that the - and I'll just take you to it at page 16 - you say that the -- let's find it here. At about lines 315:

The low volume of fish in the diet and the complete absence of Pacific herring further demonstrate the ecosystem-wide anomaly of 2007 and indicate a collapse of the plankton that are normally consumed by larval and juvenile Pacific herring.

First of all, was that -- did you do any actual plankton surveys in the Strait of Georgia that year?
DR. BEAMISH: No. We do not have measurements of plankton or prey abundance.
Q Okay. So how did you make that determination, that there had been a collapse of the plankton?
DR. BEAMISH: What we have said is that, in the paper by Rick Thomson, where we show that the physical conditions were, again, very anomalous and would be very indicative of poor plankton production, and so because the physical conditions were consistent with what you would expect to result in, well, poor prey production, and then when we then looked at the other end of the relationship that I just described to you, we said that it's most likely that with very poor physical conditions and very poor survival, that it's -- the mostly likely explanation is there was a problem with prey production that year. Herring is the best example.
Q All right.
DR. BEAMISH: So yes, we did not measure plankton production; that's an inference from the other two measurements.
Q In Dr. McKinnell's report, at page 102, he references some work by Angelica Peña on phytoplankton in the Strait of Georgia, and in the salmon farmers' list of document, that article by Ms. Peña is actually included. That's at Tab 6 of the salmon farmers' documents. It's the CSAS research document supporting the State of the Ocean Report for the 2007 year. And if you can turn to page 94 of that document. Sorry, 94 as written on the bottom of the page. Thank you.
This report looked at phytoplankton in the Strait of Georgia and it says, as you can see in the top paragraph there, that phytoplankton and nitrate concentrations were measured, in the summer of 2007, phytoplankton concentrations were

higher at most of the stations, whereas in the fall, phytoplankton concentrations were lower. How does that -- and then it also says, the second sentence says:

> The distribution of phytoplankton and nitrate concentration during winter and spring of 2007 was similar to those observed in previous years

How does that reconcile with your determination that there was a collapse of the plankton?

DR. BEAMISH: Well, I don't think this paper is saying that the prey or plankton production was normal. They're saying that -- they're reporting that they had some phytoplankton and nitrate concentrations that were measured, but I'm not aware of any publication that says that within the Strait of Georgia the plankton production in 2007 was normal. And that's not how I interpret this.

Now, I want to make another point, too, and that is that even if we had extensive plankton measurements in the Strait of Georgia, it's not a trivial matter to relate plankton production to the prey consumption of fish. But the evidence, in terms of the response of all of the fish in the surface waters that show issue -- I think I forgot to also mention that the Coho and Chinook also had a high percentage of empty stomachs. I mean, there's just no question that these fish were having trouble growing and were not surviving well.

So again, when you look at the physical evidence that's in the Thomson paper and you look at the biological evidence from the fish, I think it's most logical that there was something that was very anomalous in terms of the ability for those fish to find food, which is our interpretation, that there was something wrong with the overall production of prey in that spring of 2007.

Q All right. But this report by Dr. - I'm not sure if she's a doctor or - Dr. Peña says that the distribution of phytoplankton and nitrate concentrations in 2007's winter and spring were similar to those observed in previous years. Is that not a statement that that is a normal,

average --
DR. BEAMISH: No, I don't -- I would not interpret that to indicate that what I just said is not right.
Q Okay. And then if I could ask you to turn in your own report, which we've now marked as Exhibit 1309, at page 46 there's a figure 9 which sets out the different stomach content analysis that you did, and it shows, as you say, the Coho had very high number of empty stomachs, you can see that?
DR. BEAMISH: Yes.
Q As did the Chinook, chum -- I'm not sure if that shows up for chum, but for sockeye it doesn't seem to show that 2007 is dramatically different than the other years, and the sample sizes are very, very small for sockeye; would you agree with that?
DR. BEAMISH: Yeah, there's no question that the sample sizes for sockeye are small.
Q And that the stomach content -- percentage of empty stomachs, I should say, is not as dramatically spiked for sockeye --
DR. BEAMISH: Well, we're only looking at - I can't see the number exactly - but I recall it being around 65 fish. So it's such a -- well, the sample there is 55, but the sample is very small.
Q Right, because you would expect millions of juvenile sockeye in the Strait of Georgia, so...
DR. BEAMISH: I'm sorry, I can't hear that.
Q There's millions of juvenile sockeye moving through the Strait of Georgia, obviously?
DR. BEAMISH: Yeah, except that those samples are collected -- in 2007, they were collected in July, about not quite the middle of July, and there would not be that many juvenile sockeye in the -- not millions at that time of the year.
Q Okay. And certainly the sample sizes are much smaller than what you saw for Coho and Chinook --
DR. BEAMISH: That's true, yes.
Q -- than any others? Okay. Mr. Commissioner, I see it's 3:05. I don't know if we can press on, or if you want to take an afternoon break now?
THE COMMISSIONER: No, we can go to 3:15, that's good.
MS. BAKER: Okay, thank you.
Q Is one of the assumptions in your report that the freshwater rearing conditions for all of the stocks are similar across all populations?
DR. BEAMISH: Well, we make the assumption when we are estimating what the abundance of juveniles might

be, so yes, we do that. But we make that assumption -- we make two estimates. One, we use -- we make an assumption that you just described, but another assumption, when we estimate how many juvenile sockeye are produced in freshwater, is simply the marine survival estimate that you heard about this morning. So on one estimate, yes, we make the assumption that it's equal amongst all populations, and the other we use a marine survival estimate.
Q Which is also similar for all populations, or which is unique to each population?
DR. BEAMISH: It's a marine survival estimate that the Salmon Commission provides, that Dr. McKinnell described this morning.
Q And you also make the assumption that the sockeye that you capture in your trawl surveys, which, as you indicated, are from the tail end of the run, are representative of conditions of fish throughout the run?
DR. BEAMISH: I'm not sure I understand that. Just repeat that, please.
Q Yeah, you make the assumption -- I think you said that the sockeye that you catch are at the tail end of the run --
DR. BEAMISH: Oh yeah.
Q -- and so you make the assumption that the condition of those fish is actually representative of the fish throughout the run?
DR. BEAMISH: At the tail end? No, I wouldn't necessarily make that assumption, not the condition.
Q Okay. So when you draw some conclusions from your assessment of the condition of the fish you catch, are you saying that the condition of the fish earlier in the run may have been better than what you caught, or worse, or what are you --
DR. BEAMISH: Well, the -- we use, in the report, we use conditions for Chinook and Coho, in particular, and chum, really. The condition that we use in the report for sockeye, we actually us size and more emphasis on size. Again, the sample sizes are small, but for 2007, we point out that the length of the fish that are caught in Queen Charlotte Sound and then compared amongst the years, and the length of the fish that were caught in the Strait of Georgia, were small in 2007, and

that is an indication, recognizing the small sample size, that the fish were probably not growing well.
Q I see.
DR. BEAMISH: So I guess the answer to your question, then, would be in combination with the measurements that were made in Queen Charlotte Sound and in the Strait of Georgia, recognizing that it was a small sample size, that we use length to indicate that the growth was not good.
Q And are you simply referring to the length of the fish caught in the Strait of Georgia, or are you also using these fish caught in Queen Charlotte Sound?
DR. BEAMISH: In 2007, we're comparing the sockeye, juvenile sockeye caught in Queen Charlotte Sound and in the Strait of Georgia. There's a complication here, which I should point out, and that is, the fish in Hecate Strait, in Trudel's surveys, are consistently larger than in Queen Charlotte Sound, or in the Strait of Georgia. It's not something that has been dealt with extensively in any publication, but to me it indicates that the fish, the sockeye that swim into Hecate Strait, are definitely larger fish. In other words, they're not typical of what we're seeing in Queen Charlotte Sound or the Strait of Georgia.
Q And how long -- we've heard from Dr. Welch, he thinks that juvenile sockeye spend about 15 days or so in the Strait of Georgia, and the Preikshot report we're going to come to, says around 35 days. The other fish that you're looking at, the Chinook and the Coho and the chum and the herring, how long do they spend in the Strait of Georgia?
DR. BEAMISH: Well, first of all, I think Dr. Welch hags already published a paper saying that they stay longer than 15 days. Now, he can correct me, but I think in the -- if I had that paper I could check and see what I said, but I'm guessing that it's somewhere around 25 or 30 days that, in his previous paper that he published, and maybe he can correct me later, but I know it's longer than what he just reported.
So you then asked me about the other species and, you know, one of the issues when we wrote this paper on residence time, was coming up with a

definition of residence time. We use it rather loosely in biology, and it's not necessarily an easy term to define, so we defined it as the time that 50 percent of the population spent in the Strait of Georgia. And when we looked at that residence time, and I won't get into the details, now, because you're going to ask me about that, but that explanation is relevant to the other species.

We know, for example, that Coho stay in the Strait of Georgia well into the fall, so their residence time is considerably longer. Pink salmon, I'm not sure. I'd speculate that we catch pink salmon in the Strait of Georgia when they're there, through to September, but I suspect that a lot of them leave earlier. So I think that the residence time would be a little bit longer than sockeye. Chum, the same, probably, similar to pink salmon, and Chinook is complicated.

Very quickly, let me tell you about Chinook salmon, that the juvenile Chinook salmon that enter the Strait of Georgia first. By about August, they have either disappeared or died. By September, roughly 20 percent -- there's only 20 percent of the Chinook that entered earlier in the year as juveniles, are still there. We've put some acoustic tags on juvenile Chinook salmon in 2007, in the Strait of Georgia, and very few of them passed over the listening lines that Dr. Welch talked about.

So Chinook residence time in that first migration is perhaps a little bit longer than sockeye.

Q And herring?

MR. BEAMISH: Herring, a year or more.

MS. BAKER: Mr. Commissioner, I'm going to move to the next report now. Did you want me to start that, or did you want to take the break now.

THE COMMISSIONER: Well, we'll take a break, Ms. Baker.

(PROCEEDINGS ADJOURNED FOR AFTERNOON RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: The hearing is now resumed.

MS. BAKER: Thank you, Mr. Commissioner. I need to mark that last document I took Mr. Beamish to, which was the CSAS research document dated 2008

and numbered "/013".
THE REGISTRAR: That will be Exhibit number 1310.

EXHIBIT 1310: State of Physical, Biological and Selected Fishery Resources of Pacific Canadian Marine Ecosystems, 2008 [CSAS]

MS. BAKER: Thank you.

EXAMINATION IN CHIEF BY MS. BAKER, continuing:

Q Now, the next report that I wanted to deal with is the one titled "Anomalous ocean conditions", it's now marked as Exhibit 1303, "Anomalous ocean conditions may explain the recent extreme variability in Fraser River sockeye salmon production" and it, again, perhaps you can give us a brief overview of this report.
DR. BEAMISH: And this is the Thomson report?
Q Yes.
DR. BEAMISH: Okay. Well, first of all, let me -- can everyone hear me? Okay. That Rick Thomson, who some of you know, I think is certainly one of Canada's foremost oceanographers and he literally wrote the book on the Strait of Georgia. What Rick Thomson has done here, he has looked at the -- now, I'm not the best person to go through all of the details of his analysis.
Q Well, I'm sorry, I don't mean to interrupt, but -- I do mean to interrupt --
DR. BEAMISH: No, no, please,
Q -- but not in a rude way.
DR. BEAMISH: So I'm going to summarize what his contribution is, all right?
Q Yeah. I was just going to say if you could give us very much a high overview of what the intention of the report was and then we'll get into some detail.
DR. BEAMISH: That's all I can give you. All right?
Q Okay.
DR. BEAMISH: And it's going to be -- excuse me. There we go. Okay. What Rick Thomson has done, is that -- I do have to tell you a short story, I'm sorry, all right? I have a saying, when Rick Thomson and I disagree on something, he's right. All right?
And when we first observed that, we saw

these, what I consider to be extremely anomalous conditions in the fish, I called up Thomson and said, "You know, if you can't figure out what's going on in the Strait of Georgia, then I don't think the taxpayers are getting their money from both of us. And he accepted that as a challenge, and that's how these all -- these reports all got started.

And starting off with the freshwater discharge. He and Whitfield, if I've got it right, they actually looked at data that were not normally available, and were able to show that the freshwater discharge, not just from the Fraser River, but from all of the small rivers flowing into the Strait of Georgia, was exceptional and was anomalous. And that did result in a very low salinity.

He showed that the spring transition on the West Coast which affects the wind directions in the Strait of Georgia were again delayed or anomalous, resulting in winds blowing up the Strait and retaining that freshwater. And he did use the lighthouse data, as well as the Nanoose data, to show that there was this retention of freshwater and that the surface salinity was low. And he did make a calculation of a mixing layer depth, and I believe that he's published the two papers on it. And he did show in his calculation that that mixing layer depth was again anomalous. In fact, if I remember correctly, going back to the '70s, they hadn't seen such a shallow mixing layer depth.

So in summary then, he had clearly identified extremely anomalous conditions in the Strait of Georgia in 2007, in the spring, that we consider matches perfectly with what we -- what we would consider to be something that would affect the prey production and then result in the very poor survival that I've already reported.

Q And what was observed with respect to conditions in Queen Charlotte Sound for the same years?

DR. BEAMISH: Well, you know, again that's all part of this issue. And you've heard already that conditions in Queen Charlotte Sound were anomalous in 2007. And in this paper, we of course agree with that. Now, he argues that the anomalous conditions occurred for different oceanographic

reasons and, you know, leave that up to him to describe why. But the bottom line for a biologist like me is that the oceanographic conditions in Queen Charlotte Sound were also anomalous, which resulted in our interpretation that juvenile sockeye entering the Strait of Georgia experienced very poor conditions for growth and survival, and then those conditions were exacerbated when they moved through Queen Charlotte Sound. And in fact, the poor conditions extended right into that winter, and that's what's in that paper.
Q Okay. And what about conditions in the Gulf of Alaska in the same year?
DR. BEAMISH: In that, in the -- yes, if I remember correctly, that that winter was also a very poor winter. I think it's already been -- I think Dr. McKinnell already described that. So throughout their distribution, beginning in the Strait of Georgia, that the juvenile sockeye experienced extremely poor conditions for survival.
Q And I take it you don't rule out the impact of conditions in Queen Charlotte Sound or in the Gulf of Alaska to the marine survival of Fraser River sockeye?
DR. BEAMISH: No, not -- no, and, you know, obviously that contributed to the extremely poor returns. But, you know, I guess where the disagreement exists with my colleagues to my left, is that we said that the residence time was appropriate for these fish, consistent with the bulk of the literature, and believe me, there's dozens and dozens of papers that support that interpretation. That the conditions were appropriate, and the residence time for the average juvenile sockeye in the Strait of Georgia in 2007, all of the conditions were appropriate to have this poor survival.
And then recognizing that the critical size-period hypothesis acknowledges that mortality does not have to actually occur in the area where that -- where those conditions initially started, you can have mortality in other areas. And I have not read or heard of anyone even talking about the mortality in Queen Charlotte Sound and whatever the residence time there is, you know, it's unclear. But the concept that these fish, already in poor condition - I'm talking about sockeye now

- moving through these other areas in the ocean where they would experience equally poor conditions.
Q And what is your view, then, of the relative importance to Fraser River sockeye marine survival of ocean conditions in the Strait of Georgia, Queen Charlotte Sound and the Gulf of Alaska?
DR. BEAMISH: You know, that's an important question, okay? Because what we're talking about in 2007 is an anomaly, in my opinion. All right? And so when you ask the question like that, that would relate to sort of a general situation, the answer is that to some extent, depending on the year, these areas have importance. The relative importance is maybe a little more difficult to assign, but again, recognizing that huge amounts of mortality occur early. Skipping to the next year, 2008, with the big return in 2010, you would still have large mortalities in the Strait of Georgia, but that was followed by very good rearing conditions in the other areas. So the answer to your question is that depending on the year, those various areas will maybe have different levels of significance in terms of the overall brood year strength.
Q And I take it the kind of work that has been done in the Strait of Georgia has not -- and when I'm talking about that, I'm talking about the analysis of the condition of fish, stomach content, et cetera, that you did in the Strait of Georgia, that has not yet been done in the Queen Charlotte Sound to any large degree, aside from the trawl surveys that Marc Trudel has done; is that right?
DR. BEAMISH: That's true. And that Marc Trudel's surveys are different than ours. He makes a transect or a single transect and the sample sizes are smaller. He has different objectives.
The answer to your question is no, the kinds of surveys that we do in the Strait of Georgia have not been done in Queen Charlotte Sound.
Q Okay. And also not further up, for example, at Dixon Entrance or along the coastal Gulf of Alaska or anything like that.
DR. BEAMISH: They have been done by the United States scientists in Alaska.
Q To the same degree that you've done in the Strait of Georgia?

DR. BEAMISH: Yes. Maybe over a bigger area, but to the same degree. Yes.
Q And analyzing the relevance to Fraser River sockeye?
DR. BEAMISH: No. No. They might have some measurements, but...
Q Okay. And you've heard today some discussion about the use of Chilko smolt data as they -- smolt data, smolt numbers, I guess, as they leave the lake, and what happens to those smolts as they move through the river on their outward migration. If mortality in the river ultimately was found to be very substantial, would that change your assessment of the importance of the Strait of Georgia in overall marine survival?
DR. BEAMISH: No. No, again the - sorry - there's a couple of issues in that question. The assessment that I reported is for 2007, recognizing that that is an extremely anomalous year, all right? Now, what happens to Chilko fish or any juvenile sockeye in the freshwater is of interest. Now, again, the literature recognizes that there is mortality in freshwater, but in general most of us around the Pacific accept that we don't what it is, but we don't think it's a major issue. It may turn out to be a major issue, I don't know, but it would not affect what I reported for the 2007 issue.
Q Okay. I'd like to move to the next report, which is in our Commission binder at Tab 15. It's Exhibit 1305. And this is the report by -- with Preikshot as the lead author, and it talks about "The residence time of juvenile Fraser River sockeye salmon" and I'm thinking you probably could do a pretty brief overview of this one, because we've touched on some of these issues already, I think, so...
DR. BEAMISH: Well, we've already quickly mentioned that -- I've already quickly mentioned that defining residence time is not something that is trivial, in the sense you can just look it up and see what other people have said. But what we did here is that we used the downstream counts at Mission, as well as the Chilko counts, to identify the movement of the juvenile sockeye salmon past these counting sites. Okay? In other words we were able to document the timing of the movement

of the juveniles out of the Fraser River, recognizing that Mission is a little bit upstream of the estuary.
We then took that distribution and we matched it up with a couple of years, '97 and 2010, in which we actually had surveys in June, so that we could look at the relative abundance, or the catch-per-unit effort of the juveniles. And we identified what was almost a normal curve that was that you had to have a bit of imagination, mind you, but -- and then we matched that up with the downstream migration, and we then estimated that if the downstream migration pattern as it matched what we saw in June in the Strait of Georgia, and then knowing when they exited the Strait of Georgia, which we got from our surveys in July, so we had an entrance time, we had an exit time, we had a mean migration time in the Fraser River itself, and we had an estimate of the mean peak abundance in the Strait of Georgia. We put that all into one paper, came up with about 34 days average.
Q Okay.
DR. BEAMISH: And I'm talking to my colleague here, and I said that we actually quoted his paper, and abstract from his paper in which he got the same estimate. But I think he wants to defend himself and say that he's probably changed that. But anyhow, that's what he wrote, and our estimate was similar to what he had published, and it wasn't too far from what other people, including Mike Healey and earlier investigators had said. And some people said 30 days, and some people said longer. Thirty-five days seemed to be pretty consistent with what people had said.
Q All right. But you would agree, I take it, that there are still some uncertainties with that estimate?
DR. BEAMISH: Absolutely. And clearly that kind of an estimate needs to be improved upon.
Q In fact, unless we have a consistent survey taken at different parts along the migratory route, it's pretty difficult to actually understand the timing better; is that right?
DR. BEAMISH: How you would do that survey is, yes, I think the answer is that you would need a consistent survey. I wouldn't necessarily propose

to do it exactly the way you said, but it could be done.
Q And you would --
DR. BEAMISH: It should be done.
Q And you would also agree that being able to track individual fish moving through the Strait of Georgia would also be a good way to try and understand better the length of time?
DR. BEAMISH: Well, I'm not so sure I would agree with that so easily. No. There's some issues there that need to be considered.
Q Sure. But you would agree that if you could -- if you were satisfied that the tagging was done properly that it would certainly be a good indication of timing?
DR. BEAMISH: Well, let me answer it this way. If we -- if we put on a tag that we could be absolutely confident in did not alter the behaviour of the salmon, and we used sockeye that were representative of the population of the size range, and we had a listening line at Johnston Strait rather than northern Texada, yes, then that would be useful.
Q All right. And would you expect tagging to speed fish or slow fish down if it was to have an impact?
DR. BEAMISH: We're talking about the acoustic tag?
Q Yes.
DR. BEAMISH: I can't answer that. I don't know. But there are other ways of tagging fish that would give us that information.
Q All right. Would you agree that frequent sampling at the mouth of the Fraser and at the north end of Strait of Georgia in May and June when they're moving through would help to identify when the maximum abundance occurred for the Fraser River aggregate?
DR. BEAMISH: I'm sorry, could you just repeat that again?
Q Yes.
DR. BEAMISH: There was too many thoughts there.
Q Sure. Would you agree that frequent sampling at the mouth of the Fraser and at the north end of the Strait of Georgia in May and June, when the fish are moving through, would help to identify when the maximum abundance occurred for the aggregate?

DR. BEAMISH: I would prefer to do the study in Johnston Strait.
Q Why is that?
DR. BEAMISH: Because they have to leave through Johnston Strait and we would get the -- and it's a site that you could most likely carry on a purse seine survey that would identify the timing when the fish pass by. I just think it's a better site.
Q All right.
DR. BEAMISH: I think it's easier to do, and it's -- and you would have to repeat it over a number of years.
Q And you'd have to do it frequently?
DR. BEAMISH: Yes, over a number of years.
Q Yeah, but frequently within the season, I should say.
DR. BEAMISH: Yes. Now, I would combine that with I believe it was Dr. Welch earlier, that in one of your questions, said that sampling at Mission, sampling juvenile sockeye, absolutely. I have suggested that before. We have that site where we sample pink salmon, and if I remember correctly, that's done only in the years that juvenile pink salmon are migrating, which is in even-numbered years. And I agree with Dr. Welch, that to extend that sampling to all years, and to couple it with DNA would give us a lot of information that we need. You could most likely get an abundance estimate out of it, too, and you would tell us the stock timing or the population timing, and it would give us a good estimate of the relative abundance of juveniles coming down the river, and then compare that with something in Johnston Strait, and that would be an excellent study.
Q All right. Are you aware of work being done by some members of the Stock Assessment Group in Department of Fisheries and Oceans to sample Fraser smolt out-migrants in the lower estuary this year?
DR. BEAMISH: I retired a little while ago, so no one tells me anything any more. That's fine. I like that, actually.
I'm vaguely aware of it. The information that I had originally was that it was a valiant effort, but not large enough to really give us the kind of thing that we need to know.

Q All right. But you would --
DR. BEAMISH: But remember, I'm guessing a little bit.
Q You would agree then, I take it from what you've just said, that a sampling program at Mission as described a little bit by Dr. Welch would be beneficial in understanding the ocean impacts.
DR. BEAMISH: More than that, I think it's invaluable.
Q Okay. And you recall earlier today Mr. Commissioner asked Dr. McKinnell whether there should be additional work done in freshwater lake assessment before we start moving into more marine assessment. Do you have any thoughts on that?
DR. BEAMISH: Well, I would have answered the question exactly how we just answered it. I would have said that, you know, that carrying on the work at Chilko is obviously very important. But I would -- my next priority would be the Mission count. That's how I would answer that. And I think it -- I think it will work fine, and I don't think it's all that expensive.
Q And we don't need to do further lake assessment, smolt outmigration at the lakes?
DR. BEAMISH: Well, you know, that's a little bit unfair to the people who do that for a living, but in terms of you -- you know, money's tight and in terms of priorities and some of the other things that have to be done, that my highest priority would be to do the Mission one.
Q Thank you. I'd like to move to the last report that I want to cover with you today, and that's Exhibit 1307. It's at Tab 16 in the Commission's documents. And this one is titled "A late ocean entry life history type has improved survival for sockeye and chinook salmon in recent years in the Strait of Georgia", and you're the lead author on this one?
DR. BEAMISH: Yes.
Q All right. Again I'm conscious of time. I'm wondering if we can get a brief overview of what this work was about and what you found.
DR. BEAMISH: Can you give me an idea of how many minutes you want?
Q Well, I could just go through my questions, and maybe that would be a bit faster.
DR. BEAMISH: Okay. I'll give you -- I'll try.
Q Okay. First of all, Harrison River fish have been identified as having a different life history than

other sockeye. We've heard that already. In your work that's reflected in this document and otherwise, have you -- well, let me just ask you this. In your work that looked at the 2007 and the 2008 conditions in the Strait of Georgia, were Harrison River sockeye affected in the same way as other sockeye?

DR. BEAMISH: No, I don't think so. The -- we've heard a little bit about Harrison sockeye, and what this -- what this paper does is it also includes what we call South Thompson River chinook salmon, and again if I remember correctly, it's about 14 populations or stocks that compose that aggregate. And they also enter the Strait of Georgia much later, so the chinook enter later than the -- all of the other chinook. And they're doing very well. So the -- and then I think I said six to eight weeks later for Harrison.

Very quickly, we know that because now they -- they do maybe, and actually I think Dave Levy, who is in the audience somewhere, did some of the original work on this. But we know that they're in the estuary, and the timing that they're in the estuary, maybe we don't know that exactly. But we know that they move from the estuary, a lot of them move into Howe Sound, and then by late July or mid-August they are in the open Strait of Georgia, and then by September they're quite abundant. And then we know from the returns that they're coming back.

But this is where the condition that we talked about earlier, I think is relevant. Here are sample size is much larger in September. And when we look at the condition of these juvenile sockeye in September in the Strait of Georgia, now and we compare it to the condition in July, now there's a bit of a problem in making that comparison, but the fish are in much better health. In other words, they're fat little guys that look like they're well fed and having a nice time swimming around the Strait of Georgia.

So it is the conditions improve in the Strait of Georgia for these late ocean entry fish. It could be in 2007 that they probably couldn't get any worse, but in general the conditions I think are better in part because a lot of the juvenile salmon are leaving the Strait so there's less competition for food. But I also think that there's also -- we're seeing increases in production. So we showed that the late ocean entry, what I call life history type rather than ecotype, but what I call life history type, we showed that that consistently is producing better survival.

Q I just have a couple of questions just following up on the critical size, critical period hypothesis. And I think I did ask you some questions already about the kind of work that's been done in some of these other areas like Queen Charlotte Sound. I'm not sure if I asked you if you've done -- if any work's been done to determine residence time in the Queen Charlotte Sound area.

DR. BEAMISH: No, I don't think there has been. There was, you know, some reference to it, but it's part of this issue, and they, I would assume, that once juvenile salmon start their migration that they're going to continue on that migration. So recognizing that conditions in Queen Charlotte Sound in 2007 were also anomalous, indicating that there was poor feeding conditions, I'm guessing that the residence time in Queen Charlotte Sound is much shorter than the Strait of Georgia. Now, it's a guess. All right? But if someone has data, that would be very interesting to see. I've never seen it.

Q And why would you say it would be longer -- or shorter, excuse me, in Queen Charlotte Sound than the Strait of Georgia?

DR. BEAMISH: Because they've already started their migration. They've -- you know, they've left the Fraser River. They have to make an adjustment to the salinity. I suppose I was trying to keep this short, so I'm going to have to tell you a little bit more.

In looking at the residence time, and looking -- I actually made an estimate of the ocean entry time, and I did that by looking at the otolith. And if you -- the otolith of the fish, which is an ear bone, it records the daily growth in like lines like you would see on a -- on something that you would purchase, all right? And we were able to identify the freshwater lines of growth, a period in which there was an adjustment the fish was making to the marine environment. So there was an amorphous material in the otolith that didn't have any structure to it. And then you would see the first distinct annulus, or I'm sorry, circulus -- I'm sorry, daily growth ring, all right, or zone on the otolith. And then you could count the number of daily growth zones on that otolith and then you would count back from the day that you caught it.

I'm telling you that because you could then identify when the lake type first entered the ocean, and then when the -- and when the late ocean entry type entered the ocean.

Q Okay. But in if -- it may show that, it may show that they've been in the water for a month or six weeks, but I don't -- are you telling me that those otolith markings can tell us what days they spent in the Strait of Georgia versus Queen Charlotte Sound, or anything like that?

DR. BEAMISH: No. No, that -- you're right, that doesn't tell us how long they spent in the Strait of Georgia, but it does tell us when they started to feed. And if we know that on average they passed Mission in say mid-May, all right, or that all of them were past Mission by the end of May, and if the first feeding checks are mid-June, you know that there was a period of two weeks in which they were adjusting to the -- now, there would be some feeding, all right, but there wouldn't be the prominent feeding that you would expect.

And that's a bit -- I probably used some timeframes there that are not consistent. It wouldn't be two weeks. It would be, you know, maybe five or six days.

So it gives you an indication of the time, or what the -- what the fish was doing when it left -- as it was leaving freshwater and before it started to feed in the Strait of Georgia.

Q All right. But it doesn't actually tell us how long they were in the Strait of Georgia, or how long they were in Queen Charlotte Sound, or Hecate Strait, or Dixon Entrance.

DR. BEAMISH: No. No, it doesn't say anything about Queen Charlotte Sound or Hecate, or the Strait of Georgia.

Q Okay.

DR. BEAMISH: And that, you know, I think that the data

that we get from Marc Trudel's survey indicates that what is the sockeye, juvenile Fraser River sockeye that are in Hecate Strait, are different than the juvenile sockeye that we find in Queen Charlotte Sound. They're smaller. I didn't get into this, but we do have DNA stock composition, and there are some anomalies there. In other words, the fish from the Fraser that are in Hecate Strait are not necessarily the same stocks that we find in Queen Charlotte Sound.
Q And how many days does Marc Trudel do his surveys each year?
DR. BEAMISH: It changes, but over the years that he's been doing it, he had one or two days, maybe two days in the Hecate Strait area, Queen Charlotte Sound one day, and I think he's added something to Queen Charlotte Strait, one in Queen Charlotte Sound, but he's just changed a little bit. He's probably added a day or two to it.
Q It's a pretty small amount of surveying.
DR. BEAMISH: It's a small amount, but he has a big area to cover. But the work that he's done has been very useful. You've heard people use it routinely.
Q Earlier in these hearings an exhibit was marked which is now -- which is a 2009 briefing note in relation to the poor returns that came back in 2009. And that's Exhibit 616A. All right. Are you familiar with this briefing note?
DR. BEAMISH: Only since someone sent it to me in a binder.
Q So you were not involved in the preparation of this?
DR. BEAMISH: It's December 2009, is that what that --
Q That's what it says.
DR. BEAMISH: -- December 3rd?
Q Yes.
DR. BEAMISH: No, I don't think so.
Q All right. Could you turn to --
DR. BEAMISH: There's a small problem here. I'd better take a -- should I take a couple of minutes and tell you what the problem is?
Q Okay.
DR. BEAMISH: About this time, a few weeks after that in early January I did have a medical problem, and because my wife knew CPR and some paramedics knew what they were doing, and an emergency room doctor

and some intensive care doctors, I was able to actually be here today. But I did lose some memory. I was on ice for a while. And so there's some things I don't remember about this time. I don't remember this at all.
Q Okay. You may not be able to answer these questions, but if I could just -- I'll just try and see. Could you turn to page 2? Thank you.
THE COMMISSIONER: Ms. Baker, I have a telephone conference meeting --
MS. BAKER: Oh.
THE COMMISSIONER: -- at 4:00, and I don't want to -- if you're going to start into a new area, or go to some areas, I think it might...
MS. BAKER: Yeah, I have maybe ten minutes of questions left, so I'm afraid we'll have to come back, I guess, tomorrow with that.
THE COMMISSIONER: All right. But you have a different panel at 9:15, I understand?
MS. BAKER: We have the continuation of the gravel panel at 9:15 tomorrow.
THE COMMISSIONER: Until 10:00, is that correct?
MS. BAKER: Well, I mean, we may get through it sooner, in which case we might be able to start with these witnesses sooner, which would be great. So we are reconvening at 9:15 tomorrow.
THE COMMISSIONER: All right, then, perhaps just warn them that if they came a little bit earlier, they might get on...
MS. BAKER: Yes, I will.
THE COMMISSIONER: Thank you. Thank you very much.

(PROCEEDINGS ADJOURNED TO JULY 7, 2011 AT 9:15 A.M.)

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

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Diane Rochfort

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

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Pat Neumann

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

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Karen Hefferland