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Chair

Mr. Rodney Weston

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● (1535)

[*English*]

The Chair (Mr. Rodney Weston (Saint John, CPC)): I call the meeting to order.

Committee members, we have with us today Mr. Pennell and Mr. Harvey, via video conference.

Before we begin, I'll go through a couple of housekeeping items. We generally allow about 10 minutes per guest if you want to make any opening comments or a presentation. There are time constraints placed on our members for questions and answers.

Are there any questions before we begin, gentlemen?

Dr. William Pennell (Acting Director, Institute for Coastal Research, Vancouver Island University): Do you want some background on us first?

The Chair: Yes. You'll have 10 minutes to make an opening presentation, so you can provide background information within that timeframe.

Mr. Pennell, we'll go with you first. Then we'll move to Mr. Harvey for opening comments.

Dr. William Pennell: Thank you.

Good afternoon. I'll give you a little bit of background about myself and make a few comments that I think are relevant to this issue. I'll keep within the timeframe.

I have a doctorate from McGill University in biological oceanography. I've been teaching in fisheries and aquaculture for about 30 years ad retired from teaching about five or six years ago. I taught in Alert Bay and also in Nanaimo at Vancouver Island University.

My specialties include salmonid culture, salmonid biology, invertebrate biology, shellfish culture, and marine ecology. Regarding sea lice, I've had some field experience in the Broughtons and in the Gulf Islands over about three or four years. I was on the scientific advisory committee of the Pacific Salmon Forum, and I'm currently the director of the Institute for Coastal Research at Vancouver Island University and also a research associate at the Centre for Shellfish Research at VIU.

I want to make some disclaimers. I didn't have much time to prepare for this session—actually, just yesterday. There are some areas where I don't feel that I have expertise, so if there is any question you ask me on which I feel that I'm not up to speed with the literature, or that I feel is out of my area of expertise, I will certainly let you know.

The main point I want to make—and probably you've heard quite a few of these by now—is that a lot of money has been spent on the issue of sea lice, salmon farms, and wild salmon. I've guessed $20 million over the last decade; other people have suggested $30 million or more.

But a lot of this research was aimed at proving or disproving that salmon farms had an effect, via sea lice, on pink salmon populations. Consequently, a lot of the research did not address, in my view, critical areas of knowledge, which we need to resolve this issue.

For example, we really don't know how sea lice, in the infective stage, which is very rare in the plankton, find their host, the pink fry. We know they do, but we don't know how they do, and this is something you have to know, really, for any epidemiological study. It affects the models you would use to describe an infection and it could affect approaches to management.

We still have only a cursory understanding of how the ongoing sea lice infection on the high seas maintains itself. How that's transferred in areas without salmon farms, for example, to young fish, and their inshore and offshore life histories, we don't really know, despite many theories.

Another problem is that the sea lice we have in B.C.—and I know you've heard this before—are probably a different species. Genomics work indicates that they're different, and that stands to reason. Consequently, a lot of the information from research done in Europe over a longer time period can't be used with confidence. We don't know enough about the relative effect of temperature and salinity on our species of sea louse. We don't know enough about the precise interactions between the parasite and the host immune system, and that's very important.

We do know that Pacific salmon have a strong natural resistance to sea lice, and in other words, it's a well-adapted parasite here. But there are many other things we don't know because we're dealing with a new species, and we didn't realize this when this issue began.

Another aspect of the issue that I think you all are probably too well aware of is the rather intense polarization in British Columbia. Science works on debate, and that's fine, but the intensity of the debate here on this issue is very, very high.

● (1540)

It's greater than normal, in my view, and it's very persistent, so much so that we can find highly accomplished scientists on both sides of the issue saying opposite things and disagreeing strongly with each other. This makes it hard for the non-specialists to make a judgment when they are being told completely different things by highly qualified scientists. That's a serious problem.

Another issue that seems very important to me—although I don't know how many scientists would agree with this—is that despite all the research we do in the natural sciences, in biology and oceanography and so forth, it does not seem to solve the issue. We go from one issue to another, because the real question, I think, is whether we should have a salmon farming industry in B.C. at all. Some people feel we should, and some people feel we should not. This is the issue of the social acceptance of salmon farming.

Although all of these issues get expressed as issues of environmental concern and environmental impact, including issues of the negative effects on wild fish, I think the real issues may lie elsewhere, because we never seem to resolve them. No matter how much science we do, the argument is still healthy and alive.

I'd be happy to come back to this later, if you would like, but I think the social sciences may have as many answers for us as the natural sciences, and that's something we haven't really started to get to yet in British Columbia.

I have a couple of basic points to make. I think we were absolutely right to address the sea lice issue when it first arose about a decade ago, because it had already been an issue in Europe for some years.

But the issue here was a political one right from the start, when a large number of sea lice were seen on pink fry by local people in the province after the largest escapement of pink salmon in recorded history. They noticed sea lice on the fish, and then, a year later in 2002, in the return, the population had crashed.

The population went down from about 300 million fish to 50 million fish in one generation. That's an enormous crash. It's not unusual for pink salmon...but this was extreme. So it would be natural to look at sea lice, but sea lice were raised as the issue right off the bat by people living in that area of the province, and by people who had been trying to remove salmon farms from the area for some years.

There are a number of other quite legitimate reasons for the crash in the pink salmon population. For example, we could have too many fry for the food resource available. That's density-dependent mortality. It's a cornerstone of modern ecology and also of fisheries management. The food abundance and the timing of the emergence of the fry might have been out of whack. The fish might have been early or the food late in developing. That's a known phenomenon. Ocean conditions farther out at sea could have had an affect.

I'm not saying that these factors were in operation, but because pink salmon are known to undergo such extreme population variations and crashes throughout their range, long before salmon farms were invented and in places where there are no salmon farms, it would seem that we should have looked to at least some of these alternative hypotheses. Instead, we jumped on sea lice and stayed on sea lice, and these other possibilities have not really had a good examination. That's unfortunate.

The levels of sea lice have been reduced, both on the farms and on wild fry. Since 2005 that seems to have been a bit of a trend. We really can't tell whether this is due to some environmental change, like a lowering of salinity or a change in temperature, but one thing we do know is that the farms are either treated, fallowed, or harvested, or only have smolts before the pink fry come out.

This is an area management program that's been put together by the provincial government and the major salmon farms in the area, and I think it's fair to say that farm management has contained the risk associated with the farms and sea lice and wild fish. In other words, there is a management system now in place that should be able to manage this issue.

I want to mention sockeye, because I've noticed that there's been a lot of suggestion in the media that the declines in the Fraser River sockeye could be caused by sockeye smolts swimming past salmon farms on the Discovery Islands near Campbell River. A lot of the laboratory work done over the last two or three years has shown—while you have to be careful about transferring laboratory results to the field—that pink salmon, which begin at only about 0.2 grams or a fifth of a gram in size when they enter salt water, are vulnerable to sea lice until they get to be about 0.3 or 0.5 or half a gram. Then they develop resistance. By the time they're a gram, they're quite resistant to sea lice.

Sockeye spend an entire year in lakes, sometimes more, before they come to the ocean. They're quite big. They're smolts, not fry. They can be 3 grams or 5 grams in size, so perhaps 25 times larger than a pink fry. They have fully developed skin and scales and they should have a lot more resistance to sea lice, even if they did pick them up by going by a farm. So I think this is a non-issue, and that's a personal opinion.

● (1545)

The final thing I'd like to say is how not to do things. In British Columbia.... Well, let me just back up. It appears that the research done on salmon farms is often targeted at issues of concern to the public. That seems to make sense: you want to be solving issues that are seen to be of concern. We've seen waves of these issues, with sea lice being the most recent and also the longest lasting and probably most intense issue in recent years.

But public concern seems to originate from media coverage. So whoever gets to the media most effectively gets to set the research priorities. Essentially, if you have *The Vancouver Sun* directing research priorities, it's perhaps not the most ideal thing. In these situations, scientific work, as already noted, becomes polarized in searching for the smoking gun and so forth. There's a lot of time and money spent, wasted on casting blame and on trying to avoid blame, and this is why we did not know some of the key aspects of pink salmon biology and salmon louse biology, or sea lice biology.

If you factor in the time taken by managers and bureaucrats in dealing with this issue, I don't think we could ever really come up with a good estimate of how much the issue of sea lice has cost us—and we still don't know all that we need to know. Many less charismatic issues become neglected and money gets spent on something that has essentially been promoted by the media or people who have effectively reached the media.

So we need a new approach. I don't know what it is. I think some creative thinking needs to be done. Again, the social sciences may offer us some ways out.

That concludes my comments.

The Chair: Thank you, Mr. Pennell.

Mr. Harvey.

Dr. Brian Harvey (As an Individual): I'm going to take an approach that is slightly different from Bill's.

Hi, Bill.

Dr. William Pennell: Hi.

Dr. Brian Harvey: I think it's better for me to just describe who I am, how I got involved in sea lice, and what my expertise is. I've made the assumption that I am here to answer questions and to help when I can with information and, possibly, opinions.

As for who I am, I'm an independent biologist. I have worked independently since getting my Ph.D. in 1979 from the University of Victoria. My professional training is in fish physiology in fisheries and has concentrated on the sustainable use of aquatic biodiversity.

I have some familiarity with the biology and problems caused by sea lice because I performed two contracts for the BC Pacific Salmon Forum in 2008 and 2009. I was asked to review the relevant peer-reviewed scientific literature for research on the interactions between wild salmon and sea lice produced by the salmon farms in the Broughton Archipelago. That was my brief there. I am not a sea lice biologist. I don't have personal and professional experience in regard to doing experiments on sea lice. I did one more contract after that for the salmon forum on the threats to wild salmon in British Columbia, of which sea lice was one among many.

In the first decade of my career, I applied my training mostly to projects on aquatic biodiversity conservation in developing countries and indigenous communities. After about 10 years of that, I formed what I think was a successful—it's still going—Canadian NGO, a non-profit called the World Fisheries Trust, just to apply these research results and things I had done and published, both in Canada and in developing countries. We did a lot of training and community development kinds of things. Along the way, I published four technical books on the conservation of aquatic biological diversity.

In the third decade, I left the World Fisheries Trust to concentrate more on being an independent consultant and a writer. I specialized in two things. I wrote a number of reviews, risk assessments, and policy analyses on fisheries and aquaculture issues for some national and international agencies. Then, wearing my slightly more creative hat, I wrote and published a number of articles, columns, and books on fisheries science and development. These have been written for a general audience.

I published my first real book in 2008, which is called *The End of the River* . It is about global water management and fisheries and has a lot to do with water management in Brazil.

Some of the places where I've found funding over the years for my projects include the FAO of the United Nations, CIDA, IDRC, Fisheries and Oceans, the World Bank, the United Nations Environment Programme, the Convention on Biological Diversity, in Montreal, and a number of foundations.

I've written quite a lot of risk analyses and biological synopses for DFO. Most of these are on species that are coming under the purview of COSEWIC or are listed aquatic species at risk. A couple of those that were fairly high profile were the Cultus Lake sockeye and the Nooksack dace, which is an obscure little fish but has quite a political history.

I've been doing sustainable fisheries and biodiversity conservation in Canada, southeast Asia, and Latin America for about 25 years. At one point I led quite a long-term campaign for preserving salmon genetic diversity, so I'm quite familiar with many of the salmon problems in British Columbia.

● (1550)

I've organized and chaired numerous international conferences and workshops on aquatic biodiversity and advised the federal and provincial governments on some of these issues, as well as first nations. I've done quite a lot of work with first nations, including the Shuswap in British Columbia, the Nuu-chah-nulth, which is a collection of nations, the Musqueam, the Carrier-Sekani, and the Sliammon.

As for what I do now, I'm a consultant and a writer. In the consulting, I concentrate on these aquatic biodiversity and policy issues.

● (1555)

The Chair: Thank you very much, Mr. Harvey.

Mr. MacAulay.

Hon. Lawrence MacAulay (Cardigan, Lib.): Thank you very much, Dr. Pennell and Dr. Harvey. Welcome to both of you.

You have a lot of information, but we've heard a lot of conflicting information at this committee. We've heard Dr. Alexandra Morton. We've heard people from the veterinary side in the provincial department.

I think you're aware of what Dr. Morton would tell us, and your provincial veterinarians told us that the sea lice do come from the wild salmon in the sea, not from the fish farms. How would both of you respond to that statement that sea lice come not from the fish farms but from the wild stock?

Dr. Pennell.

Dr. William Pennell: I don't think we know. Before this issue became so prominent, sea lice on the farms were probably quite a lot more numerous than they are today, with the integrated treatment system we have. I don't think we have any way of knowing exactly where the sea lice are coming from. They've infected the pink salmon.

There are a whole lot of questions that remain unresolved. I'm not casting doubt that they could have come from salmon farms; it's perfectly logical to say that they did or that some proportion of them did. But we don't know about other reservoir populations. We don't know about the winter infection, for example. It seems to begin in December, when most of the wild fish have already come in.

There are a host of issues and questions that aren't resolved. If I'm correct in thinking that the salmon farms now have a good management approach, which means that the sea lice on the salmon farms are very reduced at the time when the young wild fish come out, then I would say we have solved the problem in a practical way, although we still don't understand the dynamics of the situation, with or without farms.

Hon. Lawrence MacAulay: Dr. Harvey, would that basically be your opinion also? Are you more or less indicating that we've spent $30 million on this issue and have learned little or nothing?

Dr. Brian Harvey: Is that your question for me?

Hon. Lawrence MacAulay: Yes. I guess it should be for Dr. Pennell, but both of you can answer, because the fact is hat we've heard a lot of conflicting information here.

And in listening to your statements, Dr. Pennell's for sure, the fact is that we know very little about the problem. That's what we're hearing. We spent a lot of money, but we know very little about what causes the sea lice. Are they resistant to SLICE? Are they not resistant to SLICE? Is that the way it should be treated? Is it the farms or does this come from the wild source? This is a big issue at the moment, I would think, on the west coast.

Dr. William Pennell: If I could qualify just one thing I said, we spent a lot of money and we have learned a lot; I just believe that there are quite a few things we haven't learned, which we might know if we had gone about things a little differently. I don't mean to say we haven't dealt with it.

Hon. Lawrence MacAulay: What I would like you to do is suggest, then, what we should do. That's what this committee would like to know: what we should do.

We understand that it's a serious problem. Are salmon in a drastic state of decline? Are they in a serious situation? Are they threatened? What measures should we take? What should this committee suggest to the government on what should be done? That's what we want to know. We're sitting here, listening to experts, and I'm sure you're telling us the best you know, but it would seem to me that people are telling us two different stories.

What should we do? What would you do if you were suggesting to the government what to do in order to do something for the major decline? Or can it be attributed to the sea lice at all?

Dr. Brian Harvey: It looks like someone is waiting for me to comment on that, so I will.

Again, the way I look at it is slightly different, because I was basically pulled in to look at the published scientific evidence for a link between the farms and the sea lice that were appearing on the pink salmon stock.

● (1600)

Hon. Lawrence MacAulay: Can I stop you for a second, Doctor? Is that the study you did between 2008 and 2009?

Dr. Brian Harvey: Yes. I did two of them. One was a follow-up. The 2009 one was just an updating of the 2008 one.

Hon. Lawrence MacAulay: Okay. That's what I would be interested in: what you really did find when you evaluated the scientific material.

Dr. Brian Harvey: Well, there was one major question asked: are the sea lice from salmon farms causing the decline of pink salmon populations in the Broughton Archipelago? That was the real question.

Questions such as where did the sea lice come from, and so on, are extraordinarily difficult technical questions of field biology, and i hasn't proceeded to the point where there is a smoking gun, but it's an extremely good hypothesis that is being tested: that they're amplified on the salmon farms and they're infecting the baby pink salmon. That's a very good hypothesis and there's a lot of evidence that this has happened.

But what I concluded...and this is going back to 2008; I'm not familiar with the last year of research on this. But I concluded that there was enough scientific argument—ad a lot of it pretty vehement argument—about whether the farm-produced sea lice were causing the decline of the salmon stocks. There was a great deal of disagreement about that, which is a healthy thing in science. That's the way science works: people disagree and eventually come to consensus. On that one question, my conclusion was that there wasn't consensus.

But there was another half to what I said, which kind of got missed, and that is that we have this thing called the precautionary principle, which is something that was put forward by the FAO over 10 years ago. There is a precautionary principle in fisheries and in aquaculture. As for what that states, I mean, it's like wearing a seat belt when you know there may be a risk that you're going to have a head-on collision. If you're not really sure, you still wear your seat belt. That's all the precautionary principle says, but it's very difficult for communities and government to grasp and to know when to apply this principle.

Certainly there appears to be an excellent case for applying the precautionary principle in terms of sea lice from salmon farms. That already seems to be happening, as Bill Pennell pointed out, with a lot more management attention to the farms. That may be why there are fewer lice and why there have been fewer and fewer lice as the years go on, since 2005. That may be the reason. I think we are starting to apply the precautionary principle, and we should continue to apply it.

Hon. Lawrence MacAulay: What I would take from your statement, then, is that there's also fair ground to evaluate that it could be just the cycle itself and not the farms.

We have heard here at this committee that the fish farms were not where they should be. They were out on the point of land where the wild fish pass on the migratory path, and they could be inland further and affect the wild stock less. In your opinion, is that valid criticism? Or is it not?

Dr. Brian Harvey: I don't actually have an opinion, but what I do have is my reading of the experts through their published research. I believe they still disagree on this issue, and that's all I'm going to say. I'm not a sea lice researcher, so I should not have an opinion on it, but the experts do not agree.

Hon. Lawrence MacAulay: Dr. Pennell, do you have an opinion on that?

Before you make a statement, you do realize that DFO has indicated that they do not have any information to indicate that sea lice are a problem.

● (1605)

Dr. William Pennell: I agree with what Brian just said.

To go back to your question on what we should do, I think we should pay very close attention to this management approach to make sure that it's effective and that the farms are actually reducing the number of sea lice and sea lice larvae being produced on the farms. If we're satisfied that this is being done, then, as Brian says, we are operating on the precautionary approach.

We should also keep an eye on what's going on in all these areas where there have been sea lice before on farms and where there are wild salmon migrating through. That means surveys. That means creating an ongoing study. That's my opinion. And then, I think, it would be nice if there were money to keep work going on some of the fundamental biological questions that still remain unresolved about sea lice.

If I could add one more thing, I think the work on oceanography and how the ocean circulation works in that area should be continued and moved to other areas, because that's going to be vital legacy research for future issues that might come up.

The Chair: Thank you.

Monsieur Blais.

[*Translation*]

Mr. Raynald Blais (Gaspésie—Îles-de-la-Madeleine, BQ): Thank you very much, Mr. Chairman.

Good afternoon, Mr. Pennell and Mr. Harvey.

My first question is for Mr. Harvey.

You say that you are not a sea lice specialist. Imagine what the situation is for us, particularly as we must make recommendations on this issue. I am not asking you to stick your neck out, but perhaps to help us out a little more. You have read a lot on this subject. Personally, I have not done so, I am learning as I go, and I understand very well that there is not necessarily any consensus on the issue.

However, according to what you have read, is it possible to determine whether or not sea lice are one of the reasons causing a decline in the salmon populations? Could there be other reasons? Could you tell us about any research you have done on the subject?

This would obviously be with a view to helping us more, because as I will repeat, the situation is much less clear to us than it is to you. Not having any formal training as a biologist, all I can really rely on is my own common sense.

Therefore, could you be of more assistance to us, rather than answering in the way that you have until now? Dr. Harvey?

[*English*]

Dr. Brian Harvey: As I understand it, you'd like me to comment on whether sea lice is just one of the factors that could be causing problems for pink salmon; I'm just saying “pink salmon” because that's really the only one on which much work has been done.

Let's put it this way. My opinion and what most scientists are writing in their research papers are the same, which is that there are many threats to salmon. Many of them interact. We don't know quite how the interactions work, but of course you would not be a good biologist if you didn't acknowledge the fact that usually these things are a combination of factors. There are an awful lot of things that have been shown to affect salmon populations.

In the United States, for example, they have a slightly different situation with their salmon, and they have what they call the "four Hs". Let me see if I can remember: harvest, hatcheries, and hydro power. What's the other one? It's habitat, of course. It's loss of habitat.

It's a little bit different here in B.C. We don't have the big hydro-power developments they have. But on the other ones, as well as things like climate change and contaminants that come floating across in clouds from smelters in Asia, those kinds of things have all been shown to affect population strength in salmon. It's highly unlikely that it's only one thing. Again, the great thing about the precautionary principle is that it says there might be 10 different things, but that doesn't do us much good when we're trying to create policy here or trying to make legislation.

By the way, I really do see your point of view about having to rely on a bunch of waffling experts who are trying to protect their positions. I do see your point of view. I do try to write for the public, to make it intelligible and strip all the jargon out, but the precautionary principle also says there might be 10 different things that are causing a problem. Which ones can you actually do something about?

In this case, there are things that can be done about harvest. There are things that can be done about some of the hatchery effects on wild salmon. There are some things that can be done to give them back some habitat. There's not much we can do about climate change in the timeframe that will affect salmon—and it definitely will—but there are also things that can be done about sea lice.

If we suspect that the harvest is a problem, we cut down on the harvest. We may not be able to actually prove that, strange as that may sound. It's not as cut and dried as that, but we suspect it pretty strongly, so we'll cut down on the harvest.

If we suspect strongly that sea lice are a problem, we'll do something about them. I believe that's happening with the kind of integrated management that Bill Pennell has referred to.

So really, I don't have an opinion that's any different from what most scientists are saying. We live in an ecosytem. There are all kinds of influences on them, and yes, there are a lot of things that are damaging to salmon. Sea lice is one of them. It may be one that we can do something about more easily than we can for some of the others.

● (1610)

[*Translation*]

Mr. Raynald Blais: I would like to ask Dr. Pennell a question.

Earlier on, during your presentation, you mentioned that we need a new approach, that we must innovate. You even talked about the social sciences. I'm having a lot of difficulty following you when you go down that path. I will therefore leave it to you to convince us that the social sciences are in some way connected to the natural sciences, as far as sea lice, aquaculture and decreasing numbers of salmon are concerned. Try and convince us that there is a place for the social sciences somewhere in this complex maze.

[*English*]

Dr. William Pennell: Okay. I'll try. I should tell you that I'm not a social scientist, although the Institute for Coastal Research, where I'm now working, is an attempt to look at coastal resource problems with an interdisciplinary approach that includes social sciences and humanities, not just natural sciences.

The point I was trying to make was that we do a lot of research and we learn things. We learn how to do a better job of salmon farming. We learn how to manage sea lice, for example, as we've been discussing.

But the real question is different; it's whether we should have salmon farming in British Columbia or not. There are people on both sides of that issue, and it does not seem to yield to scientific research. Therefore, what are the real issues? Why do people feel so strongly about this? This is where social scientists can have an impact and help us understand.

There are some questions they might answer. Why is this medium-sized industry attracting so much negative attention and what are the drivers of this? How is the industry perceived in local communities and what are the dynamics of these perceptions? What is the value to coastal communities of the jobs created by this industry? How does it compare to other industries? How do the jobs created by this industry affect community resilience?

Are there ways that the salmon farming industry could bridge the current controversies, other than waging a better PR campaign? Why are scientists frequently so strongly on one side or the other of the issue?

This is beyond the usual debate of science. Is this a common situation in natural sciences all over or is it systemic to this type of question? How do the media, the government, and the public make use of scientific discovery? How have other industries met such challenges?

Those are all questions that different branches of social science could help us with, I believe.

The Chair: Thank you very much.

Mr. Donnelly.

● (1615)

Mr. Fin Donnelly (New Westminster—Coquitlam, NDP): Thank you, Mr. Chair.

I'd like to thank both doctors for being here at the committee to provide information on this subject.

My first question is for you, Dr. Harvey. I think it's on something that you've already been talking about. You've mentioned that you reviewed 131 papers and that you put out your own review or study, I guess. I was wanting to know what conclusions you've drawn from your 2009 review.

You've mentioned climate change. At some point early in the debate around climate change, there was a degree of uncertainty and a lack of consensus, so could you keep that in mind and reflect on climate change in the debate? I'll just throw this in and you can agree or disagree: that we're now at a point where scientists have reached consensus that climate change is having an impact on many ecosystems.

Would you say the same about sea lice? Or are we too early in the review of the science and the testing of this knowledge to see if there really is an impact of sea lice on wild salmon?

Dr. Brian Harvey: We were too early in 2009, when I was reviewing the papers that I could find on the topic, but to back up, you asked another question about what my conclusions were at the time.

On the question of whether sea lice from salmon farms were causing the decline of pink salmon populations, I did conclude that the jury was out on that, and that people did not agree on that. As Bill Pennell has pointed out, they did not agree, and they did so in a pretty strenuous way. There were rebuttals and chains of counter-rebuttals on papers. Again, I hadn't really seen very much in the scientific literature before. The scientists seemed to be emotionally invested in this debate.

On climate change, there has been research going on for a lot longer than probably most people realize. I was just reading Carl Sagan's last book. He was a great scientist and also a great writer about science. This book was written just before he died in the mid-1990s. He has a long chapter in there on climate change. Even then, within the scientific community, there was pretty much a consensus.

So no, we hadn't reached that point in 2009 with sea lice. But I think what we had reached was a point where I had absolutely no difficulty believing that sea lice from salmon farms were infecting wild pink salmon—absolutely—but there did seem to be some effects of management in reducing the sea lice that could get out of salmon farms and that were amplified in the salmon farms.

Probably one thing nobody has mentioned here that I think is quite important is that we can't just say that we seem to have found a way to reduce the numbers of sea lice and it's "problem solved". If it's being reduced by management that includes the use of a pesticide, we have to make sure that is not having any detrimental effects, or at least effects that society will not accept.

Climate change—

Mr. Fin Donnelly: Could I just jump in here? I'm sorry. Unfortunately, I don't have much time, and I have one other question.

In the next round I'll ask Dr. Pennell a number of questions, and they do relate to SLICE and the application of SLICE, but before my time runs out, I just want to ask you, Dr. Harvey, about the issue of risk analysis and the precautionary principle.

Given what you have reviewed and given some of the questions you've just been asked about management, do you have a suggestion or recommendation in terms of the type of technology that's being used by the aquaculture industry currently, i.e. open net versus closed containment?

● (1620)

Dr. Brian Harvey: I don't there, but I do have a recommendation on what they're calling the integrated pest management strategies. There are now area plans that are beginning to emerge. I do have a recommendation that those be refined and monitored, heavily monitored, and that we keep a very close eye not only on the numbers of lice, which do seem to have gone down, but on whether there are any side effects of these management plans. I mean, clearly that's the bargain you have to make.

Mr. Fin Donnelly: Thank you.

The Chair: Thank you.

Mr. Kamp.

Mr. Randy Kamp (Pitt Meadows—Maple Ridge—Mission, CPC): Thank you, Mr. Chair.

Thank you, gentlemen, for taking the time to appear before us. I appreciate it.

Let me start with Dr. Pennell.

Just so I understand a little bit more of the zoology, when we're talking about the infectious stage of sea lice, what stage is that? Are we saying that there are adult lice on fish farms that reproduce, so there are larvae, and that it is those larvae that grow to some infectious stage and then attach themselves to some species of fish?

Can you just clarify that for me? Then I have a follow-up question on that issue.

Dr. William Pennell: Yes. Starting with the female fish with eggs, the ovigerous female—and in this case, let's say it's an Atlantic salmon on a farm—the female produces two long strings of eggs. I've forgotten how many eggs; I think maybe 900 to 1,000 per female. These eggs hatch into what's called nauplius larvae, and they go through three stages of non-feeding moults, when they shed their outer integument and grow.

The fourth stage is called the copepodid, and it is a stage that has a little filament that it can use to attach to a host. All these four stages that hatch from the eggs are carried in the currents and the plankton, and at the infective stage, which is a few days of life in which it has to attach to a fish, when it bumps into a salmon or somehow finds a salmon—and it's usually a salmonid of some sort, but it could be a stickleback or a herring—it attaches.

Then it goes through a whole series of moults while it's attached. It gets larger and larger and finally becomes an adult male or female. They mate, and more eggs are produced. The whole process, depending on temperature, takes about 45 to 50 days.

Mr. Randy Kamp: So for my follow-up question, then, how much work has been done to know if that actually happens in the vicinity of these fish farms?

Specifically, I'm curious about what your opinion is on the work of Kenneth Brooks, who has done some work suggesting that, given where these farms are located, with the salinity and currents and so on, these sea lice are not in an infectious stage while the smolts or young salmon would be swimming by these farms, and they're further out.

At least, that is my understanding of his conclusions. I just wondered what you think of that, Dr. Pennell, and perhaps Dr. Harvey as well.

Dr. William Pennell: I think I might be on the edge of my abilities to give you a good answer. I think he's probably right in that there are extreme tidal currents, not transport currents, and back-and-forth sloshing tidal currents in this very complex area known as the Broughtons.

I think that probably we're looking at about eight or 10 days from hatch to the infective stage. In that time, those animals could have moved quite far from the farm of origin. But I don't think that's an important issue. They're adding to the overall pool of infective stages in the area, and therefore if there is or was a farm contribution, it doesn't have to take place right beside the farm. It could take place downstream or upstream.

Just to repeat something I said earlier, it's quite a fascinating biological mystery how these infective planktonic stages, tiny little things, manage to find their hosts so effectively. They do find them. But when you take a plankton sample and try to sample them from the plankton with a fine mesh net, I think as Brian said in one of his reports, you're looking at one or two larvae in a volume the size of a living room. We don't know quite how they manage to do it, but they do it.

● (1625)

Mr. Randy Kamp: Thank you for that.

Dr. Harvey, do you have anything to add on that particular issue?

Dr. Brian Harvey: Yes. First of all, there was just a sense of wonder when I got to read all of this stuff; there were a couple of hundred papers I had to chug through. And yes, it is extraordinary that they manage to find a host. It's also very interesting about how fast our ability to look at the effects of currents and wind on these tiny particles is; you have to remember that this is going way beyond anything we knew about current movement, about the movement of water, and yet suddenly that's very important, so we have to learn and create models.

Ken Brooks' theories are based on mathematical modelling, in which you take the best information you have, create a model, feed the model with the information, and come out with a conclusion about what you think might be happening. There are other mathematical models, and there are quite a few from Europe, where perhaps the fjords are different, so you can't really extrapolate. So I think we're maybe 60% of the way to understanding how a louse might get from A to B.

Nevertheless, as Bill says, if the salmon farms have a lot of lice on their fish and they're amplifying the numbers of lice that could come from the wild and they're dumping out there, then again, the precautionary approach is to say, okay, this may be causing a problem, so let's see if we can reduce them on the farms, which is, I think, what is starting to happen.

Mr. Randy Kamp: Those are good points. I appreciate that.

I have one final question, Dr. Pennell, and then I'll turn it over to Ms. O'Neill-Gordon, if she has any follow-up questions.

Dr. Pennell, you commented on sockeye, but you went past that pretty quickly. The whole point of the commission of inquiry that's taking place at the moment and will be continuing for a while longer is to find out what might be causing the decline in sockeye. In the terms of the reference, one of the things is aquaculture.

I want to see if I understood you correctly. You seemed to be saying that you couldn't see how lice from aquaculture operations could be playing a significant role in that decline. Did I understand that correctly?

Dr. William Pennell: Yes. However, I want to clarify that what I gave was an opinion, and you could get a different opinion from other people. I based that opinion on the general results of laboratory work, which show that juvenile salmon—in this case, mainly pink and chum salmon—become more resistant to sea lice the larger they get.

They're the smallest of the salmon. A chum salmon would be about a quarter of a gram when it comes out into the river, and a pink salmon maybe a fifth of a gram. They are very, very tiny. They don't have fully developed scales when they first arrive in salt water, so they're quite vulnerable; at least, that's the conclusion that a lot of researchers have come to.

As they grow older, they get a more complex integument and start developing scales and perhaps other immune responses, because fish have an increasing immune response as they get larger. For any number of those reasons, they seem to become more resistant.

Sockeye salmon are smolts. They've already spent a full year in a lake, and in some cases two years, and they're much larger. They are 25 to 30 times larger than a pink fry and they have fully developed scales; therefore, I would suspect them not to be particularly vulnerable to sea lice.

Now, I don't know that anyone has done work with sockeye to prove this, so it's a bit of a conjecture, but I thought that of all the many things that could be affecting sockeye salmon populations in the Fraser, sea lice are perhaps the least likely.

That's my opinion. You might want to get another opinion from some of the DFO scientists.

Mr. Randy Kamp: Okay. Thank you for that.

Do you have a final comment on that, Dr. Harvey?

● (1630)

Dr. Brian Harvey: Well, it's very early in the game to say what's causing the decline in sockeye. It's a classic case, in the sense that there are many, many factors. As for whether it could be sea lice or not, what's the evidence? That's what any biologist wants to say: what is the evidence? If it's a hypothesis, fine, it's a hypothesis. We already have two hypotheses: one is that it couldn't be and the other is that it could be.

Actually, that's probably not a particularly difficult thing to test. If you want to make decisions that are based on science, then who cares what people's opinions are? This is testable.

Mr. Randy Kamp: Good. Thank you very much.

The Chair: Gentlemen, on behalf of the committee, I'd like to thank you very much for taking the time out of your schedules to be with us, discuss your positions, and share your opinions. We really do appreciate it. As you can appreciate from the questions you have received today, the committee is really searching for information, and we appreciate your taking the time to provide that.

Thank you very much, gentlemen.

We will take a short break as we prepare for our next witness.

● (1630)

(Pause)

● (1635)

The Chair: I call the meeting back to order.

I would like to welcome Mr. Krkosek.

Mr. Krkosek, I know you were here for the first part of our meeting, so I probably don't need to go through it again. We allow 10 minutes. You'll hear the beeping noise. I know you've already witnessed that here a few times.

Mr. Krkosek, we really appreciate your taking the time today to come and appear before our committee. Hopefully we can have a great discussion and carry it on a little further. I'll turn it over to you at this point, if you'd like to make any opening comments.

Dr. Martin Krkosek (Research Associate, School of Aquatic and Fishery Sciences, University of Washington, Seattle): My name is Martin Krkosek. I'm currently a research associate at the School of Aquatic and Fishery Sciences at the University of Washington.

I've been working on the sea lice and salmon issue for just over eight years now. I received my doctorate from the University of Alberta for work that I did on this issue two and a half years ago. I've received numerous awards for that work, including a Governor General's gold medal. I've written approximately 20 papers on this topic over the years, including some of the most significant papers in the top journals that have received a large proportion of the media interest on this issue.

I'd like to thank you for having me here. It's an honour to come here and be able to communicate with you on this issue. I have prepared a briefing document for you. Unfortunately there's no French translation at the moment, but it should be forthcoming.

I agree with most of what my colleagues said in the previous hour. I'd say there's been a large focus on what we do not know about this issue and not so much of a focus on what we do know about this issue, and I'd like to speak to that a little bit.

Four key questions are at the heart of this issue, and I've been working on those questions. The first one is whether sea lice spread from salmon farms to wild salmon. Second, if they do, what's the impact on individual fish in terms of their behaviour and in terms of their survival? Third, if infestations are recurrent, what's the effect on the populations of wild salmon that are affected? Finally, if all this amounts to a problem, what are the management solutions that can be implemented, if any? I've been working on all these questions over the last eight years.

The first question is whether sea lice spread from salmon farms to wild salmon. I think there's an overwhelming amount of evidence to indicate that they do. Salmon farms are not the only source of sea lice in the environment; in fact, sea lice are a natural parasite, and they were here long before the salmon farms were here. What's different is the point in time when transmission happens and the magnitude of that transmission.

In the absence of salmon farms, when juvenile salmon leave the rivers and lakes and enter the nearshore marine environment, they do so in the spring, in March, April, May, and June. During this period there are very few natural hosts for sea lice in the nearshore environment. Most of the hosts are offshore; they're adult salmon, and they're out there on their feeding migration. It's not until summertime, in July or August, that large populations of wild salmon return to the coast and bring sea lice with them. This means that there's about a three- to four-month window between the time juvenile salmon enter the ocean and the time they first encounter sea lice. It's during this period that they're smallest and most vulnerable to infection.

There is a key difference when salmon farms are in the water. They provide a very large host population for sea lice during the winter, so when juvenile salmon enter the nearshore marine waters, they encounter salmon farms that host several million domesticated hosts in a region like the Broughton Archipelago, and those hosts support a large parasite population. When the juvenile salmon enter the ocean, they encounter those parasites, and they're poorly equipped to handle them. That is where the concern is: the effect of sea lice on the very small juvenile stages of salmon during their first few months of marine life.

What we've learned is that in areas without salmon farms, the natural prevalence of infection is about 5% on juvenile salmon during this stage of their life. In areas with salmon farms, the prevalence has a wide range, but it's generally higher than that, and in some instances can reach 90%, 95%, 100%. There is sometimes a very high mortality associated with very high infestations.

You don't have to be a mathematician to figure it out. I've been in the field studying this for about six months of the year for the last eight years, and you can see it happening.

● (1640)

The effect of the sea lice on the juvenile salmon can be direct mortality. One adult louse on the smallest salmon is lethal. The more common situation is two or three lice on a medium-sized juvenile salmon, and there, the interactions are much more subtle. There will more likely be sublethal effects that make the fish more prone to, primarily, predators or diseases. It's probably there that mortality happens. The lice change the behaviour of the juvenile salmon in ways that make them more prone to predators. So in reality, in the ocean, long before a louse would kill a fish, a predator would kill that fish because of the infection that was there in the first place.

There was a period of about five years when we had recurrent, very large, sea lice infestations of juvenile salmon in the Broughton Archipelago. Those were the infestations that triggered this issue. During that time, we observed very high mortality among the juvenile salmon. Using standard fisheries and epidemiological tools, we were able to isolate the effect of sea lice from numerous other confounding factors and identified that as a major factor affecting the productivity of wild pink salmon populations in the Broughton Archipelago. During that period of infestation, the productivity was negatively affected so much that the populations were at risk of local extinction.

Since then, we've seen major changes in management. It has moved from a focus on protecting the productivity of the farms to a focus on protecting wild salmon from sea lice. It's a coordinated area management plan; most of this work is still focused on the Broughton Archipelago.

During the spring, when the juvenile salmon migrate out to sea, about half the farms are emptied or are treated with chemical parasiticides to bring the lice numbers down as low as possible during that out-migration season. Preliminary results indicate that this management plan is working. The number of lice on the farms and on the wild salmon have declined dramatically in recent years.

As scientists, with the models we're using, we would predict that this should result in the recovery of those populations. The predictions we made in the past, when we were expecting to see local extinction because of sea lice infestations, now no longer hold. The sea lice infestations have been largely eliminated from the Broughton Archipelago because of this change in management.

The change in management is largely reliant on the use of chemical parasiticides, and this is a situation that is, I think, a little bit tenuous. First, one reason is that the chemicals could have adverse effects on the aquatic ecosystem. This is toxic to crustaceans. That includes shrimp, prawns, crab, and the copepods in the zooplankton that are a key component of the food web. To date, no one has done any work to evaluate what the ecological effects of these chemicals are.

Another tenuous aspect of the use of these chemicals is the possibility that sea lice will evolve resistance to these chemicals. This is an outcome that has already happened in New Brunswick, Norway, and Chile. Based on our experiences in these other areas, we would expect a similar outcome in British Columbia, although that outcome may be slower.

However, this last winter, we had our first evidence that Slice treatment—emamectin benzoate, known as Slice, which is what is used—failed in one area of British Columbia, Nootka Sound, and this suggests that sea lice may already be evolving resistance to the chemicals used in British Columbia.

However, it's not the only explanation. Other explanations are also possible, such as that the dosage was incorrect or that the salmon were not feeding well and did not receive the correct dosage. No one has done the work yet to determine whether sea lice have evolved chemical resistance in British Columbia.

So far, most of the work in British Columbia has been focused on pink salmon in the Broughton Archipelago, and that's where we have made our largest advances in understanding the science of sea lice and salmon and in understanding the effectiveness of new management.

● (1645)

I would like to point out, though, that in all major salmon-farming regions of British Columbia, primarily the Discovery Islands, the Broughton Archipelago, and Clayoquot Sound, we have the same patterns of sea lice infestation and population decline of wild salmon. This includes pink salmon, chum salmon, coho salmon, chinook salmon, and sockeye salmon.

It's likely that the problems we've seen in the Broughton Archipelago are widespread. However, it's also likely that there are management solutions that can deal with this. Those management solutions depend on the long-term sustainability of the chemicals that are used to control sea lice on farms.

The Chair: Thank you very much.

Mr. Dhaliwal.

Mr. Sukh Dhaliwal (Newton—North Delta, Lib.): Thank you, Mr. Chair.

Thank you for coming here today and making this presentation.

More than a year ago in British Columbia, there was a Pacific Salmon Forum that submitted some recommendations. Do you agree with those recommendations? If so, can these recommendations form a public policy?

Dr. Martin Krkosek: I would agree with some of those recommendations, particularly changes in governance of the salmon resource that are more holistic and encompass the entire freshwater ecosystem as well as the nearshore marine environment. Currently, management is separated into too many disjointed units that are not speaking to each other.

They have a recommendation that exposure to sea lice should be minimized during the most juvenile stage of the salmon life history. I would agree with that, but I think there's a danger in over-focusing on those earliest stages. Although those are the ones that are most vulnerable, the older stages are also vulnerable, depending on how many sea lice are in the environment and for how long the salmon are exposed.

It's easy to produce mortality in juvenile salmon if you expose them to enough sea lice for long enough, and the conditions we have in British Columbia mean that exposure to sea lice for all species of salmon during the juvenile stage can be high and can be chronic. It takes about two to three months for some species of salmon to migrate through a zone of salmon farms.

Mr. Sukh Dhaliwal: For those two recommendations that you agree with, do you see that the federal government has already taken action on them, or do you believe the government should take action, or that we as a committee should recommend that they be implemented?

Dr. Martin Krkosek: Particularly on governance of the salmon resource, I'd like to see some of those recommendations implemented.

Mr. Sukh Dhaliwal: The judicial inquiry into the whole diminishing salmon stocks in the Pacific Ocean has been in question.... I mean, it will come in the future. What do you see that we can do immediately, right now? Even when you say management...you don't believe in closing those farms, right? Is there anything that we as a committee can recommend that can be taken care of immediately?

Dr. Martin Krkosek: I think the largest risk to wild salmon from salmon farms is disease transmission. It's not just sea lice. There's a very long list of viral and bacterial pathogens that we know are transmitted between wild and farmed salmon.

The current locations of the salmon farm tenures in British Columbia are on the main migration routes of some of the most significant salmon populations in Canada. The salmon farms are on a collision course with the wild salmon migrations twice a year. In the fall and summer, when the adult salmon return to spawn, they pass the salmon farms, and the farmed salmon are at risk for all those pathogens. In the spring, when the juvenile salmon migrate out to sea, they are at risk of infection from those pathogens that may be on the farmed salmon.

Spatial planning of aquaculture in British Columbia needs to be thought about very carefully, I think, certainly if there's continued development in the future. Particularly for the issue of Fraser River salmon stocks, I think, the collection of salmon farms around the Discovery Islands is a very big problem. Situating salmon farms in areas that are distant from wild salmon migration routes would be a key change that could be implemented.

Another one that I would recommend, which follows on the experience from Norway, is setting aside protected areas for salmon ecosystems where salmon-farming activity is prohibited. These would be marine protected areas where the wild salmon have no salmon farms that they are exposed to during their return and out-migration.

● (1650)

Mr. Sukh Dhaliwal: DFO has told this committee they do not know if the fish farms are causing a decline in the wild salmon populations. Would you like to comment on that?

Dr. Martin Krkosek: I would agree that the published science from DFO does not show any effects of salmon farms on wild salmon stocks.

I would disagree that science in general shows that. There's a long list of scientific publications that show negative affects of salmon farms on wild salmon stocks; it's just that they're not authored by DFO scientists.

The Chair: Monsieur Lévesque.

[*Translation*]

Mr. Yvon Lévesque (Abitibi—Baie-James—Nunavik—Eeyou, BQ): Thank you, Mr. Chairman.

If I may, I will call you by your first name, which is easier in French than Krkosek. I will call you Martin.

You heard the testimony of the two people who spoke before you earlier on. There is an issue that bothers me and I'm going to raise the subject with you. We discussed a product called SLICE. That is the company name, but not the scientific name of the product.

I would like to know if this product was tested only on sea lice or if it was also tested on fish? We are using a product that attacks the sea lice, but if we are using a sledgehammer to kill a fly, could it not be the product itself in the end that kills the fish?

[*English*]

Dr. Martin Krkosek: Is this going to affect the health of the salmon that are receiving the...? Yes?

[*Translation*]

Mr. Yvon Lévesque: Could it go so far as to kill them?

[*English*]

Dr. Martin Krkosek: I think that at sufficiently high doses it could cause a problem for the health and well-being of the fish. But at the dosages they receive to control sea lice, it's not a concern for the health of the fish that receive that treatment.

[*Translation*]

Mr. Yvon Lévesque: I was asking you if the product was tested on fish as well as on sea lice? Is it a product that was strictly tested as far as the elimination of sea lice is concerned, and in using it, are we attacking the fish itself at the same time? Is that possible?

[*English*]

Dr. Martin Krkosek: I think it's a product that has been examined largely for its effectiveness in killing the parasites, and less so on the health and physiology of the salmon, though some work has been done on that as well.

[*Translation*]

Mr. Yvon Lévesque: So we have not done studies to see whether or not the product is contributing to the declining fish stocks. If the fish stocks are diminishing at the same time as the sea lice numbers, which are perhaps more resistant to the product than the fish itself, we are increasing the number of lice in comparison with the remaining salmon.

[*English*]

Dr. Martin Krkosek: That's an interesting question: is the chemical itself a problem for the wild salmon? I doubt that the chemical itself, through exposure to wild salmon, would cause them a problem.

Where there may be a problem is in the effects on the food web of wild salmon, because the chemical is toxic to crustaceans. That includes copepods that live in the zooplankton and are an important component of the diet of juvenile wild salmon. If the chemical residues in the environment are sufficient to affect those copepod populations, then that could lead to a decline in the food resource for wild salmon.

However, this is all speculation. No one has done this work.

● (1655)

[*Translation*]

Mr. Raynald Blais: Thank you, Mr. Chairman.

Thank you sir.

Quite frankly, I would say that your presentation and the answers you are giving us have brought great clarity to the issue. I understand much better thanks to what you have said, and I'm anxious to read your document, once it has been translated into French. In your presentation, at the very beginning, if memory serves me well you mentioned that there were four factors to take into consideration. We discussed one factor, that being the location of the aquaculture sites in relationship to the wild salmon. There were three others. What are they?

[*English*]

Dr. Martin Krkosek: Well, when I started, I said there were four main questions at the heart of this issue. First, do lice spread from farmed salmon to wild salmon? Second, what is the effect of sea lice on individual juvenile salmon, on their survival and behaviour?

Third, what is the effect on wild salmon populations of the infestations that happen recurrently, year after year? It's a big step to go from effects on an individual fish to the productivity of the population. Then, finally, there is the fourth question: if we believe that we have a problem, what are the management solutions to this problem?

[*Translation*]

Mr. Raynald Blais: There may be other factors that are causing problems for the wild salmon, including all species. We talked about climate change, and normal animal behaviour. There may be many other factors to consider. Among those other factors, setting aside the issue of sea lice, what would be the other factors that we should study, in order of priority?

[*English*]

Dr. Martin Krkosek: Certainly, there are numerous factors that affect salmon populations, varying from population to population. In some cases, it would be the loss of freshwater habitat. In other cases, it could be pollution. In other cases, it could be dams. In others, it could be disease from aquaculture facilities or hatcheries. In others, it could be problems with the harvest and overharvesting. Another important factor is climate change, and that's a very big, looming factor.

All of these things contribute to the decline of wild salmon in British Columbia. Not all of these things are amenable to management solutions. If I were to rank the factors we were to focus on, I would look at disease transmission from aquaculture as a very important factor.

I would do so, first, because our experience from the rest of the world indicates that we should expect problems; second, because we are seeing problems in B.C.; and importantly, third, these problems are amenable to management change and solutions. Other problems such as climate change are a lot more difficult to deal with.

[*Translation*]

Mr. Raynald Blais: Thank you very much.

[*English*]

The Chair: Thank you.

Mr. Donnelly.

Mr. Fin Donnelly: Thank you, Mr. Chair.

Thank you, Dr. Krkosek, for coming today and providing your testimony.

I have a number of questions that I'll throw out at once. If there's time, I may have a follow-up question. You seem quite confident that there is definitely a problem with sea lice affecting wild salmon, whereas we've heard previously at this committee and from other scientists that the evidence is inconclusive, or that it's hard to say, or that there are two camps at opposite ends of the spectrum that essentially don't agree with your conclusion.

So that's my first question: how are you so certain about the conclusion you're drawing?

Second, I'm wondering if you could comment on the tolerance of Slice on the west coast. There's been comment to this committee that there is not a problem in British Columbia. Could you confirm that this is the case, in your opinion? Also, if you happen to know how testing occurs for drug tolerance, could you comment on that, as well as on who does the testing, if you know, and how often those results are reported or published?

Finally, as you recommended management solutions, could you finish by commenting on what your top priorities would be for this industry, if there were, for instance, a recognized conclusion that sea lice are affecting wild salmon and an agreement that sea lice needed to be addressed? What would be the first things that should be addressed?

● (1700)

Dr. Martin Krkosek: To answer your first question, my level of confidence in believing that sea lice are a problem for wild salmon comes from working on this issue for eight years. I spend about half my time in the field catching fish, counting sea lice, and doing experiments on the effects of sea lice on juvenile salmon behaviour and survival. I spend the other half of my time analyzing those data and working with mathematical models that tell us the implications of what we're learning.

During that time, I also read the literature. The convergence of evidence would be one where sea lice are a contributing factor to a decline of the wild salmon populations. As for where my colleagues differ, I think the main argument is that they're not the only factor. I would agree with that as well. Numerous factors affect salmon populations. Some of them we've known about for a long time.

I would say that sea lice are a new factor, and that does contribute to the productivity of wild salmon populations. What we've learned from the European experience and in British Columbia is that they can be a major factor affecting salmon populations. It takes time in the scientific community to look at new results like this and time for independent people to do their own work and reach consensus. We're in that stage where these are pretty new results, especially in British Columbia.

But the overwhelming weight of evidence from my assessment, from the literature and from the work that I've done, is that sea lice from salmon farms are a major problem for wild salmon populations. It's not only my work; a lot of other people have arrived at the same conclusions. But it's also a problem that is amendable to management change and management solutions.

The second question is about tolerance of sea lice to Slice. The first possible indications that this is happening in British Columbia come from Nootka Sound, from this winter, where there was a failure of treatment on one or more farms in that area where treatment with the chemical was made. The subsequent decline that we usually see in the sea lice populations on the farms was only small, and the sea lice populations rebounded very quickly after that. Those are the telltale signs of resistance to a chemical.

However, this is all anecdotal, and neither I nor anyone else has done the work with those lice from that area to determine whether or not tolerance has evolved.

Let's move to the next question. That work is being done by the centre for aquatic animal health, based in Campbell River, and I believe they're working not with the sea lice from Nootka Sound but with sea lice from other areas. The way they do it is to expose the sea lice to different concentrations of the chemical, and they determine the concentration that causes 50% mortality in the lice. That's called an LD_{50}, and they look to see how that concentration at the LD_{50}changes. As the lice evolve resistance, it takes more and more Slice to kill them.

Do I have time to address the final question about the management solutions?

The Chair: Very quickly.

Dr. Martin Krkosek: Very quickly, early indications are that coordinated area management with chemical treatment and fallowing appears to reduce sea lice numbers. It looks like it's having the desired effect. I think that's a more fundamental change. Moving the farms away from wild salmon migration routes would be far more effective and would relieve the tenuous reliance on chemical treatment. This should be done in the context of spatial planning, whereby areas should be set aside for wild salmon ecosystems where they're not exposed to these risks.

● (1705)

The Chair: Thank you very much.

Mr. Allen.

Mr. Mike Allen (Tobique—Mactaquac, CPC): Thank you, Mr. Chair.

I have a few questions for Dr. Krkosek, and if I have time left...I guess Randy said that about Tilly, too.

We'll see how it goes, Tilly.

Welcome. Thank you for being here.

In your analysis when you were doing some of these studies—I'm thinking about baseline data—you said that the sea lice were prevalent in the area, that they're there anyway. What kinds of numbers did you see? Was there any baseline data done, with, then, the aquaculture laid on top of that to kind of understand it?

You did say in your remarks that if there is a non-farm situation, the issue with the small fish is 5%, potentially up to 90% or 100%. What did you determine as a baseline for a sea lice count, if you could ever do that, as opposed to what it would be in aquaculture?

Dr. Martin Krkosek: Sure. The rule of thumb that's emerging is that in the absence of salmon farms during the first two to three months of marine life for juvenile Pacific salmon, the prevalence of infection is approximately 5% or lower. That number comes from areas where there are no salmon farms. It does not come from areas before salmon farms were implemented there.

We only started studying this issue after the salmon farms were there and we started seeing these problems. So in order to get baseline numbers, we have to look elsewhere in British Columbia, where there are no salmon farms, and compare spatially—exposed versus unexposed—rather than before and after salmon farms come in.

Mr. Mike Allen: You have those baseline numbers, and as per what the last people talked about, wherever you go, this whole situation is going to be different. On that spatial issue, are you going to run into other challenges? Do you have the data of what that baseline is in a non-aquaculture scenario?

Dr. Martin Krkosek: I would say that it would be 5% of infection right now, which appears to be about the limit of what we see on juvenile salmon during their first few months of marine life with Lepeophtheirus salmonis, which is the salmon louse.

Now, there are other species of sea lice out there that do tend to be more prevalent during this phase of their life history, but the salmon louse is the species that is the problem, and the baseline levels for this species are approximately 5% in areas without salmon farms.

Mr. Mike Allen: Again, without the numbers, I would only have to draw the conclusion that you're saying it would be 20 times the amount of lice. Is that what you're trying to say?

Dr. Martin Krkosek: In areas with salmon farms?

Mr. Mike Allen: Yes.

Dr. Martin Krkosek: It depends on numerous factors. The range in areas with salmon farms is anywhere from approximately 5%, when management is effective, to 95% to 99% when management is not effective.

Mr. Mike Allen: You talked a lot about the pink salmon. As we noted before, Mr. Pennell said there have been huge swings over the years in terms of the pink salmon returns and what that means.

Was there any correlation done between those returns on salmon—let's talk about over the last number of years—and different impacts, whether it be climate change or whether it be other factors? Also, here's the second part of that question: have you assessed anything on the sockeye?

Dr. Martin Krkosek: Yes, we have done those analyses, and in epidemiology we'd call it a matched case-control study, where you have two sets of populations that are experiencing the same environmental conditions. One subset experiences the infestation, the other does not, and you look to see if there is a change in their productivity.

In an analysis, we've applied that kind of structure to pink salmon populations on the central coast of British Columbia, looking at changes in productivity of these populations, before and during the sea lice infestations, in relation to an unexposed area just to the north of there. The structure of the analysis allows us to control for other compounding factors that are environmental and affect the populations as a whole—-so that would be large-scale climatic fluctuations. The model we used is a non-linear stochastic model, which allows us to control for environmental noise as well as density-dependent mortality.

With this analysis, we're able to isolate the effect of the sea lice infestations on the productivity of those populations. We've done that for pink salmon in the Broughton Archipelago. I'm part of a group that has now finished a similar analysis for coho salmon in this area. We're beginning to put together analysis of chum salmon in the Broughton Archipelago.

We're also starting to assemble the data to look at the relationship between sockeye salmon productivity in the Fraser in relation to aquaculture production, but we're only in the early stages of assembling the data for that.

● (1710)

Mr. Mike Allen: How much time is left, Chair? Four minutes? I'll turn it over to Ms. O'Neill-Gordon.

Mrs. Tilly O'Neill-Gordon (Miramichi, CPC): Thank you, Mr. Chair.

Welcome.

As you know, as a group we have certainly been acquiring a lot of information on this topic and we've been hearing topics on both sides of the issue.

Here's my question for you today. Of course, as we know, the committee was told there were significant differences between the sea lice living in the Pacific Ocean and those living in the Atlantic Ocean. Coming from the Atlantic side, I wonder what these differences are, and what is their relevance to the infestations in farmed and wild salmon, respectively?

Dr. Martin Krkosek: I think that's a really interesting and important question. The differences between the Pacific and Atlantic forms are genetic.

Mrs. Tilly O'Neill-Gordon: I see.

Dr. Martin Krkosek: They've looked at the genes of these different groups and have determined that they're sufficiently different genetically to constitute different species.

Now, that does not mean that there is any meaningful difference in the traits or the ecology of these species. No one has looked to see if there are differences in the life history of these species, in their pathogenicity, in their host specificity, and so on. In general, they have the same life history, the same life cycle, and similar sensitivities to temperature and salinity.

I think there's a lot we've learned from the Atlantic form that is transferrable to the Pacific; we just have to be cautious about how we do that.

Mrs. Tilly O'Neill-Gordon: What is the origin of those differences? In your opinion, are the two types of sea lice different species or are they the same species but with different genetics?

Dr. Martin Krkosek: Well, it's subtle. It depends on how you define species. When taxonomists separate populations into different species, they look at the genetic divergence between them. They're sufficiently genetically divergent to constitute different species, because they've been isolated for a long time.

Mrs. Tilly O'Neill-Gordon: Thank you.

The Chair: Thank you.

You have two and a half minutes, Mr. Calkins.

Mr. Blaine Calkins (Wetaskiwin, CPC): Thanks, Dr. Krkosek. My name is Blaine Calkins. I'm a graduate of the University of Alberta with a zoology degree. I'm going to ask you a couple of questions.

I want to know about the life cycles of the five different species of anadromous salmon in the Pacific Ocean. I specifically want to know at what point they re-enter the Pacific Ocean with the various lice. We know from previous testimony that the sockeye are much larger, and the pinks are much smaller. Can you comment on the other three species and let us know?

I would like to know about the shelf life or the bioaccumulative toxicity of Slice. I would like to know how persistent it is in the environment and how long it persists after its the application on the farms.

I'd also like to know the infestation-to-mortality ratio of the lice. As the infestation rates or prevalence of the lice on a particular salmon increase, do we see that once they get to four or five, it starts becoming lethal?

Also, do you have any other information about the indirect mortality caused by sea lice? I would like you to elaborate on that.

Dr. Martin Krkosek: We have five species of salmon in the Pacific Ocean. Most of the concern about sea lice is focused on pink and chum salmon. The reason for this is that when they hatch from gravel in the rivers, they go straight to the ocean as fry.

The other three species—sockeye, coho, and chinook—overwinter or spend at least one year, sometimes more, in fresh water. When they leave the freshwater systems and move to the ocean, they're substantially larger; therefore, we would consider them to be at lower risk of sea lice infestation than the pink and chum, which are very small when they first encounter the sea lice.

There are also anadromous forms of cutthroat trout and rainbow trout that move between fresh water and salt water, and they tend to be overlooked. No one is really studying—

● (1715)

Mr. Blaine Calkins: So you're talking about steelhead and so on.

Dr. Martin Krkosek: Yes, steelhead—

Mr. Blaine Calkins: What about the Dolly Varden? They're anadromous as well.

Dr. Martin Krkosek: Yes, that's true, and no one is looking at these species from a sea lice perspective.

You also asked about the persistence of Slice in the marine environment.

Mr. Blaine Calkins: You talked about the fact that it's toxic to all copepods and crustaceans, so my question is, how long does this stuff persist in the environment after it's applied?

Dr. Martin Krkosek: Right here, I don't know how long the chemical remains viable in the marine environment; I'd have to look it up and get back to you with those numbers.

Mr. Blaine Calkins: Okay.

If we do have time, Chair, just one—

The Chair: We're going to have another round.

Mr. Blaine Calkins: Are we? Okay.

The Chair: Mr. Andrews, for three minutes, please.

Mr. Scott Andrews (Avalon, Lib.): Thank you, Mr. Chair.

Thank you, Martin, for being here today.

I want to get back to what Mr. Allen was talking about. He was talking about the percentage and a 5% natural prevalence rate. You said that when they're going by the salmon farms, the prevalence rate was up to 95%, and you seemed to let that go a little bit when you said that it was up to 95%. Could you give us a little better idea of that particular percentage?

Dr. Martin Krkosek: Well, it varies from year to year. In the worst years, when the infestations were the most intense, the prevalence of sea lice was up to 99% in some locations, with the number of lice per fish reaching 80, 90, or over 100 lice per juvenile salmon. Those numbers, obviously, are lethal.

In other years, when there were fewer farms that were active or where chemical treatment or other management actions reduced the number of lice on the farms, we saw more moderate levels of infestation: 30%, 40%, and 50% as well. It's variable from year to year.

Mr. Scott Andrews: We've had officials here from the B.C. aquaculture department. They've gone into some of these salmon farms and have done their own statistical models on how much sea lice are on the salmon in the farms themselves.

Now we're talking about wild salmon. Can you do an analysis of what their statistics are saying about the sea lice that are on the salmon in the farms and at the same time what they're saying is on the wild salmon outside the farms? Is there a model you can use to show that what they are saying is factual or correct? And can it be correlated?

Dr. Martin Krkosek: As part of this new coordinated area management plan, we're working on sharing the kind of data that comes from the farms and the data we collect in the field, to put them together to do exactly what you described.

I can tell you that in years when the sea lice infestations were very high, the numbers of the sea lice on the farms were about five, six, or seven motile lice per fish. From the perspective of farm husbandry, this would not be considered a problem for the health and well-being of the farmed fish.

However, those numbers correspond to a major problem for the health and well-being of the wild juvenile fish that are migrating by. The reason for this is that the number of fish in a farm is so high—between half a million and a million—and sometimes there are several farms on a migration route, so that the actual production of lice, even if it's only three or four per fish.... If you multiply that by two million or three million fish, that's a lot of lice in the environment.

Mr. Scott Andrews: As far as the management plan goes, as it exists now, is it working? Can we have the coexistence of salmon farms and wild salmon and still protect wild salmon?

Dr. Martin Krkosek: I can say that the new management plan, which uses fallowing and chemical treatment, has been effective at reducing lice numbers on farmed fish. It's been effective at reducing lice numbers on wild fish.

Based on the numbers we've seen, we would expect recovery of the wild salmon populations in these areas, but it's too early to say. This all depends on the long-term sustainability of the chemical treatment being effective.

Mr. Scott Andrews: Thank you.

The Chair: Thank you.

Monsieur Blais.

[*Translation*]

Mr. Raynald Blais: I would like to raise two factors with you that we have perhaps not touched on until now: they would be pollution and marine traffic.

We understand very well that an ecosystem can be on a large or a small scale. And I understand that the Pacific Ocean, the area that the salmon occupy, its habitat, is big enough for several factors to be taken into account.

I was wondering if pollution in general is another factor that we should be paying attention to. Is shipping traffic, which is on the increase, I imagine in these areas... There are also invasive species. We may have all kinds of questions to ask ourselves. Do you have any solutions to propose as far as those factors are concerned? Or once again, has this already been studied in some way?

● (1720)

[*English*]

Dr. Martin Krkosek: You want to know if they have been examined in connection with the general decline of salmon populations in British Columbia. As far as shipping traffic goes, I don't think so, not with regard to salmon, but people do look at shipping traffic for effects, particularly on killer whales and other cetaceans that hunt by sound. That can interfere with their communication with each other and locating prey.

Pollution can have a very large effect on ecosystem dynamics. It can change the productivity and ecology of the plankton, which has ramifications for everything above the plankton in an ecosystem. There are multiple sources of pollution, usually associated with industry and large human populations, but also with the waste material that comes from the salmon farms. That addition of nutrients to an ecosystem can change the dynamics of the plankton, which can have implications. But as far as I know, there is no detailed work looking at that.

[*Translation*]

Mr. Raynald Blais: What about invasive species now?

[*English*]

Dr. Martin Krkosek: Invasive species are a major factor globally in the change in ecosystems. At the moment, I'm unaware of any invasive species in British Columbia that would be contributing to the decline of wild salmon populations. That's not to say there isn't one; I'm simply unaware of one.

The Chair: Thank you.

Mr. Donnelly.

Mr. Fin Donnelly: Thank you, Mr. Chair.

I have two questions.

I'm wondering if you can comment on the effect of the farm salmon density on sea lice infestations.

Secondly, a comment was made earlier to this committee to the effect that DFO scientists essentially agree that there is insufficient information to suggest that lice on farms are affecting Pacific salmon in a detrimental way. Can you comment on that?

Dr. Martin Krkosek: As far as farmed salmon density goes, one thing that we've learned from the ecology of infectious diseases, epidemiology, is that disease dynamics are highly sensitive to the density of hosts. When you crowd animals together, or crowd people together, diseases tend to break out.

What this means is that there may be some things, like critical host density thresholds, where, within a region like the Broughton Archipelago, if the regional density is relatively low, there may be fewer disease problems. When the density is very high, there may be a lot of disease problems.

It's very difficult to say where that threshold might be, but I would say that it's likely a factor. It might be a reason why a place like the Broughton Archipelago transitioned from a place where we did not have sea lice problems to one where we do now. A similar thing has also happened in the Bay of Fundy in New Brunswick, where, as the density of farmed fish increased, suddenly sea lice emerged as a problem. It wasn't a gradual shift. It was a sudden shift.

As far as the position of DFO and DFO science is concerned, there's insufficient evidence to conclude that there is a problem with sea lice and Pacific salmon. I would disagree with that. I think there's ample evidence to indicate that we have a problem. I think there's ample evidence to indicate that the problem is a lot bigger than we think it is. It's more expansive spatially to other areas of British Columbia, as well as to other species of salmon. That would be my position.

● (1725)

Mr. Fin Donnelly: Thank you.

The Chair: Thank you.

Mr. Calkins.

Mr. Blaine Calkins: I'll keep going. I'll fire a few more at you, Doctor, and we'll see how this goes.

On the idea that tolerance to Slice may be becoming a factor in this one particular incident, would it not be more likely to be one of the other factors, given the fact that if it were a tolerance that was being built up, we would see it not only in one location, but we would actually start seeing it on a broader scale? I don't think we wouldn't see it in isolation. This appears to be an isolated incident. I would like to know what your scientific opinion is on that.

Second, as a scientist, you have a wish list. In your own research, what do you wish you knew that you didn't? What are some of the things that you would like to see, as far as complementary research happening on the Pacific coast right now is concerned, to complement the knowledge base, to fill in the gaps in the knowledge base?

I've asked this question before. I don't know if anybody's done any work or run a statistical model on it based on the known patterns of salmon migration. Is it possible for a pink emerging from the Fraser River to swim north and not come within...? Based on the patterns that we know, what are the odds of that young salmon that is swimming north avoiding a fish farm completely, versus not doing so? I don't know if anybody has looked at the statistics for that, but if you could enlighten me that would be great.

Dr. Martin Krkosek: I'll answer the last question first.

In the Broughton Archipelago, we've been able to work out that the spatial sea lice footprint of an individual farm is about 30 kilometres, so in a radius of about 15 kilometres around the location of a farm, you will see elevated numbers of sea lice over what would naturally be there. If that same size of footprint holds for the Discovery Islands area, I would say that it is not possible for a juvenile salmon to migrate north on the inside of Vancouver Island without being exposed to a salmon farm.

On your first question, I agree that there are several explanations for why the Slice treatment in Nookta Sound failed. Resistance in sea lice is one possible hypothesis; there are others. It's not possible to distinguish among those hypotheses at the moment. The data is not here. Depending on that being an isolated event, that being unlikely, I think it depends on how much connectivity there is among sea lice populations on the coast there. We don't know how connected the population of sea lice in Nootka Sound is compared to other populations in B.C. If they're widely connected, then you'd expect to see the same treatment failures we saw there starting to happen elsewhere in British Columbia. At the moment, it's too soon to say.

As far as my wish list is concerned, I'd like to have accessible records on the number of fish per farm, as well as records of mortality events and disease outbreaks for all types of diseases for all farms in British Columbia. I think this is critical information that we need to look at to see if there is a reason why this could or could not be connected to problems in wild salmon productivity in British Columbia.

The Chair: On behalf of the committee, I thank you very much, Dr. Krkosek, for taking the time today to appear before this committee and answer our questions.

Committee members, if you have any witness lists, please submit them to the clerk, the analysts, or me. Please don't forget.

Once again, thank you very much, Dr. Krkosek. We really appreciate the time you've given us.

Dr. Martin Krkosek: Thank you for having me.

The Chair: The meeting is adjourned.

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