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ARTICLE

A Tale of Two Food Risks: BSE and Farmed Salmon in Canada

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ABSTRACT Today the public has access to enhanced resources for interpreting the technical basis of risk communication messages, emanating from government and industry, dealing with food risk issues. These resources include extensive media reporting on key scientific studies as well as Internet sites, hosted by many different players, where the scientific and statistical basis for risk assessments are presented, debated, and criticized. In this information-rich context risk managers are challenged to present a clear, forthright, and honest account of the scientific and statistical underpinnings – including uncertainties – for their risk estimations. We discuss these issues in the context of two recent Canadian food risk cases, BSE in cattle and farmed salmon. In the BSE case the government's risk communications failed to accurately express the nature and scope of the risk as it had been evaluated by government officials in technical documentation; specifically, the complex statistical manipulations served as a smokescreen behind which was hidden the true – catastrophic – risk, namely, that the discovery of even a single case of BSE in the Canadian herd would have "extreme" consequences for the entire group of small, independent beef producers. In the case of farmed salmon, our study shows that the contaminant numbers are open to differences in interpretation among government agencies, and that understanding the level of risk is no simple business. The industry should have acted years ago to ensure that the public was provided with reliable resources for understanding the nature of chemical contaminants in fish and the risk assessment methodologies used for determining safe levels of consumption.

KEY WORDS: Risk, risk assessment, risk management, risk communication, BSE, farmed salmon

Introduction

Risk issues generally, and food risk issues in particular, pose a number of challenges for the interested public (Leiss, 2001). Without a doubt one of the

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most severe challenges is in understanding and appreciating the scientific research and statistical analysis that lies behind, and supports, the technical risk assessment. Quite often, the body of prior research and analysis is vast and complex – and, in some cases, it is still evolving toward a more complete picture of the risk. In stark contrast to this complexity, however, stands the usual simplistic response of government officials to a potentially worried public, "Trust me, this food is safe to eat." Few among them may know how unstable the feeling of trust is when it comes to food (Frewer *et al.,* 1996; Lang and Hallman, 2005; Poortinga and Pidgeon, 2005).

In the age of the Internet and expanded scientific literacy this standard response becomes increasingly problematic. For example, both print and electronic media now routinely include discussions of new scientific research findings in daily newscasts, especially for risk issues that are likely to be salient in the public mind. Often, when this occurs, the reporting will include interviews with persons who appear to be equally reputable but who interpret the scientific findings in different – or opposite – ways (Schütz and Wiedemann, 2005). Second, for the large segment of the public which has access to high-speed Internet connections, some initial acquaintance with a risk issue can easily open a whole world of information, expert and non-expert opinion, and, arguably, misinformation. A notorious case in point is the alleged link between MMR vaccine and the risk of autism and other diseases.[1] And there can be second-order consequences that flow from these new developments: As is well-known, the alleged MMR/autism link led to a significant drop in childhood vaccinations in the U.K., requiring public health authorities to mount a campaign to reverse the trend.

There is every reason to believe that these tendencies – where science and risk assessments become a matter of public debate – will strengthen with each passing year. We suggest that these tendencies impose new requirements on government officials and others who must communicate with the public about risk factors, namely, to be more forthcoming and explicit about the scientific and statistical complexities inherent in technical risk assessments. For example, in the case of the MMR vaccine, the "enhanced" discussion, resulting directly from the controversy, necessarily expanded to include elaborate relative-risk estimates (since vaccination is itself not risk-free) and risk-benefit discussions. We believe that those who – in industry and government – bear risk communication responsibilities, and who wish to be regarded as trustworthy, must get themselves prepared to engage in these more elaborate interchanges about risk assessment.

What is true of risk issues generally is doubly the case for food risk issues, which are especially sensitive for the public. Looked at from the other side, in matters of food both governments and industrial firms face having

[1] See the extensive government websites on this issue (U.S. Centers for Disease Control and Prevention, 2004; U.K. National Health Service, 2003).

even a risk classified as negligible "blow up in their faces." In the following pages we present two cases of recent food risk issues in Canada, in both of which events unfolded with startling rapidity. Both illustrate the need to engage the public more fully with respect to the inherent complexities of food risk assessments. In our conclusions, we seek to draw these two lessons for effective risk communication (RC), which go beyond the standard "trust" doctrine: (1) risk managers need to be able to craft RC messages which transcend the level of "formulaic" responses ("food is safe") and address the unique features of a specific controversy; (2) in an age when the public has access to varied information sources, RC messages must strive to embrace adequately both the rich complexity and the uncertainties in the scientific and statistical-analysis basis of the risk assessment.

BSE comes to North America

In the period between May 2003 and August 2006, seven cases of bovine spongiform encephalopathy (BSE) were discovered in the Canadian herd, an episode that has had devastating impacts on Canadian farm families and the country's farm economy. By November 2003 – a mere seven months after the initial case – the estimated negative economic impact (direct and indirect economic costs) from a single case of BSE had already exceeded $5 billion.[2] The personal and family costs among farm families are incalculable. How could this have happened, as a result of a few sick cows? How could this have happened, since no one thinks – on a comparative-risk assessment – that the health of Canadians is seriously compromised if meat from a few cattle infected with BSE had entered the domestic food supply over a period of years?[3]

First, BSE did indeed have catastrophic consequences in Canada, but not as a result of issues linked directly to the safety of food. Second, governments in Canada brought on this catastrophe by mismanaging the risk of BSE. Specifically, government officials failed to identify and manage the single most serious risk to a specific segment of the Canadian public, namely, the

[2] Serecon Management Consulting Inc. (2003) estimated $3.3 billion in direct economic costs and $1.8 billion in secondary impacts as of that month. At the time of writing (July 2006), a possible sixth case had just been reported.

[3] The Canadian government position is that there are no known cases of BSE-infected cattle having entered the human food supply. Since BSE in Canada is a relatively rare disease, there is a strong probability that there have been other, undetected cases in the Canadian herd which were missed with the so-called "passive surveillance" system, under which only animals showing clinical symptoms of disease are excluded from the food supply. For a disease such as BSE, which develops slowly (5–6 years on average), this can lead to underestimation of disease prevalence; see Supervie and Costagliola (2006). Under a policy of "active surveillance," on the other hand, implemented both in Japan and the EU, apparently healthy animals are routinely tested after slaughter. But if it is fair to say that it is very likely that there were other, undetected cases of BSE in the Canadian herd, it is also unlikely that there were very many of them. See Comer and Huntley (2004) on the situation in the U.K.

risk of economic catastrophe – and its attendant social consequences – to the independent beef producers in farm communities. They failed to communicate to beef farmers and the larger agricultural industry the true risk, that is, the best estimate of the likelihood that BSE would show up in the Canadian herd – and, if it did, what the consequences would be. The truth is, there was always a fair likelihood that North America would see a few cases of BSE in its herds. There is still a fair likelihood that one or more additional cases will appear in the coming years.

There are terrible ironies in this whole episode. The normal excuses given by governments for failing to communicate risks effectively is that "the public may panic." With respect to BSE, public panic can be reflected in sharp drops in beef sales, as happened in Japan (which was in fact a collapse in the public's trust in government as regulator of food safety). In the case of Canada's troubles with beef, however, this excuse is unavailable: Canadians responded to the terror of BSE by *increasing* their consumption of beef, which – since prices did not drop – probably reflects both the public's love of beef and its desire to make a generous gesture of support to the ever-struggling farm sector (cf. Raude *et al.*, 2005).

BSE – bovine spongiform encephalopathy or "mad cow disease" – is one of a larger class of animal diseases called transmissible spongiform encephalopathies (TSEs).[4] They may arise spontaneously (sporadic cases) and can also be acquired by transmission; they can also cross the species barrier. The best-known member of this class is scrapie, which affects sheep (BSE may have originated as a mutation of scrapie); others include CWD (chronic wasting disease) in deer and elk, and feline spongiform encephalopathy (seen in both domestic and wild cats). A number of the cases, such as those in mink, cats, and a wide variety of hoofed animals kept in zoos, are attributable to the feeding of animal protein infected with scrapie and BSE. CWD still presents challenges to science in terms of its origins and mode of transmission. The human form of sporadic TSE is Creuzfeldt-Jakob Disease (CJD), which is transmissible through direct contact with infected nerve or pituitary gland tissue (corneal transplants, growth hormone implants). Another acquired form, caused by infection from BSE, is known as variant CJD (vCJD).[5]

BSE has been one of the highest-profile issues in animal health and food safety around the world for over fifteen years now. The early history of the issue is well known. First, the British beef industry was decimated, giving rise

[4] See Ridley and Baker (1998) and Lasmézas and Adams (2003). Two good websites are School of Biological Sciences, University of Leicester (2004) and Priondata.org (n.d.). There is now a National Centre of Excellence on prion diseases in Canada: PrioNet Canada (2006).
[5] The U.K. government estimates that the infectious dose for cattle can be as low as 0.001 gram (U.K. Department for Environment, Food and Rural Affairs, 2005). The minimum infectious dose for humans in contracting vCJD is not yet established. Health Canada (2006a) simply states: "In Canada, BSE continues to pose an extremely low risk to human health."

to countless tragedies among farm families and running up costs against the public treasury in excess of four billion pounds sterling. Next, it spread to over twenty other countries, including most of the European continent and as far away as Japan, where the dual difficulties of farmers and public costs have been repeated. The most plausible explanation for the global spread of BSE is that it resulted from the exporting of infected feed, live cattle and other bovine materials from Britain. The feed exports were the worst of these: The official report of *The BSE Inquiry* (Philips *et al.*, 2000, p. 70) in Britain confirmed that British officials permitted these exports to continue in full knowledge that some portion of the feed certainly was infected. As the issue evolved over the course of the decade 1986–1996, there were major failings in risk communication (Leiss and Powell, 2004, ch. 1; Wiedemann *et al.*, 2005).

BSE came to Canada and to the United States as well initially through imports from Britain of small numbers of live animals that were infected, which were rendered following slaughter and subsequently contaminated the domestic animal feed supply in both countries. What follows is a quotation from a draft risk assessment document prepared by a Canadian federal department in mid-2000 but never either completed or publicly released: "Therefore, live cattle and sheep imported from the U.K. during the early 1980s, and possibly before this, up until the time of import bans could have served as a vector for the introduction of BSE to Canadian livestock either through direct animal contact or through consumption of animal feeds produced with rendered materials of imported animals" (Orr and Starodub, 2000).[6]

And yet the nature of this risk was known to Canada's national risk regulator for animal health at least as early as May 1994, when an internal report – entitled "Risk Assessment on Past Importations of Cattle from France, Switzerland and the U.K." – was prepared, *but never released to the public*. The report (Animal, Plant and Food Risk Analysis Network [APFRAN], 1994) states:[7]

- 'The probability of entry of BSE infected cattle through the 1982–89 importation of 183 cattle from the U.K. appears to be very high;'
- 'further cases of BSE [in addition to the one found to date in this cohort] would likely prompt a trade embargo against Canadian exports of cattle, beef and dairy products for an indefinite period of time by some or all importing countries"; "domestic consumption of beef and dairy products could diminish considerably … [and] necessitate changes in rendering policies;'

[6] The study was never completed and this draft report was never released to the public (it was obtained under an Access-to-Information request). Andrew Nikiforuk (2004) first revealed it in *Business Edge Magazine*.

[7] It was obtained by one of us (Leiss) in 2005 pursuant to an official request under Canada's Access to Information Act.

- 'the economic impact including foreign trade losses and domestic public reaction gives this disease a high impact rating.'

We are aware of no evidence that there was any direct and public communication of the nature of this (economic) risk, from the national risk regulator to the beef-producer industry – which as of May 2003 consisted of 90,000 small producers – *at any time* between May 1994 and May 2003, a period of nine years.

Instead, for next nine years the risk regulator labored in private on an elaborate quantitative risk assessment. When it finally appeared, in December 2002, Canada was a mere five months away from the discovery of its first indigenous case in May 2003. The following statement is found in the Executive Summary (Canadian Food Inspection Agency [CFIA], 2002a):

> The estimated probability of at least one infection of BSE occurring prior to 1997 was 7.3×10^{-3} and therefore the likelihood of establishment of BSE in Canada was negligible. The risk was even further reduced by the mitigating measures in place since 1997.[8]

But buried deep in the third section, positioned almost as an afterthought following a recitation of extremely complicated statistical analysis, is another exceedingly simple, but utterly devastating judgment (CFIA, 2002b): "*If BSE was introduced, the consequences would be extreme*" (our italics).[9] This statement was never extracted from its hiding-place in this technical document and communicated directly to the beef producers. It is almost impossible to imagine that the ordinary beef farmer would have had the time or patience or skill, between bouts of caring for his herd, to wade through the pages of mathematical expression to find what he needed to know – and to find it in time to digest its meaning and consider his options.

But note also that in the Executive Summary – which might have attracted some notice on the farm – CFIA (2002a) describes "the likelihood of establishment of BSE in Canada *prior to 1997* as "negligible." The dictionary definition of the word "negligible" is, "so small or unimportant or of so little consequence as to warrant little or no attention: TRIFLING." How did the "very high probability" of the entry of BSE into the herd – as of the internal document of May 1994, cited earlier – become the "negligible likelihood" of BSE being "established" in the herd as of 2002? This appears to be a linguistic sleight of hand: If "established" – a word not further explained in the document – meant "similar to what happened in the U.K.," where the disease was spreading quickly through the national herd for some

[8] The "mitigating measures" refer to Canada's partial feed ban: See Leiss and Powell (2004, pp. 247–249).
[9] See Appendix A below.

years, then it is true that BSE was unlikely to become endemic in the Canadian herd, since after the early 1990s officials in other countries, including Canada, were on the lookout for the disease.

But that is not what Canadian beef producers most needed to know as of December 2002, when CFIA's Risk Estimation document was finally released. What they most needed to know was that the occurrence of even a single case would have devastating consequences for them – because they were exporting 75% of their cattle by 2003, and their export markets would close instantly if a single case were to be found. Indeed, this is exactly what occurred: Canada's BSE crisis of 2003 was a disaster waiting to happen.

In its evaluation of the period after 1997, the Agency simply asserted – *without any supporting argument whatsoever* – that, in view of policy choices made in 1997, namely, the partial ban on feeding ruminant material to ruminants – the risk thereafter was "further reduced" from "negligible." It is hard to say what the phrase "further reduced from negligible" actually means: "Infinitesimally small"? "Too small to measure"? In any event, no statistical calculations at all were adduced in defense of this judgment. And yet, if you were a Canadian beef farmer in, say, December 2002, what would you care about the risk as it was before 1997? What you needed at that point in time, and should have had in hand from your government, was some solid estimate of the risk you were facing at that moment.

Why were the consequences of finding a single case of BSE in a national herd in 2003 so catastrophic? The reason is, during this time, Canada and other nations subscribed to an international policy on BSE which is straightforward and brutal in its consequences: If you are a country exporting beef, and you have just one indigenous case of BSE in your herd, you're out of the beef export game *for seven years*.

The standard formula for risk estimation is: $R = P \times C$ (risk equals probability times consequences).[10] The consequences of finding only one

[10] For fuller details see "Two Stinking Cows," chapter 10 in Leiss and Powell (2004, pp. 240–245), where the following table appears on p. 245:

Frequency \ Consequence	Catastrophic	Critical	Marginal	Negligible
Moderate				
Low	BSE			
Very Low				
Minimal				
Negligible				

case in the Canadian herd were qualitatively assessed as "extreme," *but this judgment was never factored into the overall risk assessment*. In other words, CFIA's risk assessment actually amounted to the formula R=P: The frequency estimation alone was allowed to stand as a proxy for the risk assessment, which is contrary to the most basic principles of standard practice, where $R=P \times C$. When consequences are factored in, as they always should be, the risk ranking level for BSE in Canada as of late 2002 – as assessed by CFIA – was in fact a state of "intolerable" or "catastrophic" risk. What they should have said to farmers, in language that could not be misunderstood, was something like this:

1. "There's a fair likelihood that anywhere from one to a few indigenous cases of BSE will show up in the Canadian herd."
2. "Since Canada and other countries subscribe to a policy of 'one cow and you're out,' beef producers in Canada should be fully aware of the reality that others will shut their borders *immediately* to our beef if even one indigenous case of BSE is discovered here."
3. "You should also be aware that, in the event even one indigenous case of BSE is found in our herd, international trade agreements to which Canada is a party provide that we will not be allowed to resume exports of beef and beef products until a full seven years have passed following the last case."

What would beef producers in Canada have done, in the years between 1997 and 2003, if they had received these three messages, loud and clear, from their industry and their governments? Would they have continued building up a huge beef herd, 75% of which was destined for export after slaughter? Or would at least some have concluded that this was an utterly unreasonable risk for producers to take – *provided that* they had been informed in clear language about this risk by the federal regulator, as they should have been, but were not. Beef producers in Canada were not told the truth about either the actual risk or the devastating long-term consequences that might follow therefrom.

The lingering tragedy still unfolding around us on Canada's farms arose in large part because the people who speak on behalf of our institutions, principally those in the federal and provincial governments, have never learned how to use the language of risk appropriately. Instead of telling Canadian beef producers – in effect – that BSE wouldn't happen here, they ought to have said, "Yes, it could very well happen, and if it does, the economic consequences will be devastating."

These officials knew that the first case (called the "index case") would bring an economic disaster to Canada's beef producers – because this fact is clearly acknowledged in a CFIA technical publication published, ironically, shortly before May 2003 (Morley *et al.,* 2003, p. 178): "The risk estimate … indicates a negligible probability that BSE was introduced and established in Canada; nevertheless, the economic consequences would have been

extreme."[11] Subsequent events have shown that the second part of that statement, at least, was brutally accurate. In the light of this knowledge, the appropriate risk management strategy – the one that should have been strongly recommended to Canadian beef producers for the entire period between 1997 and 2003 – would have been, to restrict the growth of the national herd until the risk had diminished (as it will with time).

Repeated and longstanding failures in the accurate communication of risk are at the heart of what went wrong in the mismanagement of BSE risk in Canada. These failures occurred in the entire period after 1997, when Canada and the United States adopted a set of policy choices about BSE risk in response to the belated acknowledgment by the government of the UK, in 1996, about its own catastrophic failings in this regard.

Farmed Salmon

On 9 January 2004 Ronald Hites (Indiana University) and David O. Carpenter (State University of New York at Albany), along with others, published an article in the prestigious scientific journal *Science*. This study was the most comprehensive to date to explore the issue of chemical contamination in farmed salmon on a global scale. The research found significantly elevated levels of chemical contaminants and insecticides such as PCBs, dioxin, dieldrin and toxaphene in farmed salmon as compared to wild salmon. These contaminants have been associated with a range of health problems including cancer and immunological, endocrine and developmental problems.[12] The article recommended that consumers limit their consumption of farmed salmon from less than one to up to eight meals per month, depending on where in the world the salmon was raised. This was because the degree of contamination varied by country, with European farmed fish containing higher levels of these contaminants than those from Chile or North America. The salmon farmed in British Columbia and Nova

[11] Note that the authors – who were the CFIA employees in charge of the Risk Estimation exercise – here refer to the "negligible probability that BSE was *introduced* and established in Canada" (our italics). We have discussed earlier (page 11 above) what the word "established" probably meant. But "introduced" is very different. The "introduction" of BSE into Canada is what the May 1994 document (APFRAN, 1994) was referring to, in the statement quoted above on pages 9–10: "The probability of entry of BSE infected cattle through the 1982–1989 importation of 183 cattle from the U.K. appears to be very high." In this published article of 2003 Morley *et al.* (2003) – on the basis of no new evidence or argument – convert the earlier "very high probability" estimate to a "negligible probability" one. We apologize for taking the reader through this tedious argument about how arbitrary changes in qualitative measures may stand side-by-side with the most exacting quantitative risk assessments. (For another notorious example – the infamous "Alar" episode – see Leiss and Chociolko, 1994, ch. 6.) But these qualitative expressions are the words that form the basis of risk communication messages.

[12] PCBs, dieldrin, and toxaphene are classified by the U.S. Environmental Protection Agency (2006a, 2006c, 2006d) as class 2B or probable human carcinogens. Dioxin is classified by IARC as a "known human carcinogen" (World Health Organization, 1999).

Scotia were some of the least contaminated in this report, although the researchers recommended that people consume less than 10 meals per month of any of the salmon farmed in Canada. Less than one meal per month was the recommended limit for salmon farmed in Scotland and the Faroe Islands (Hites *et al.*, 2004). The authors used the U.S. Environmental Protection Agency's (U.S. EPA) risk assessment protocol to determine the acceptable number of meals that consumers could eat. This protocol is used across the United States to develop advisories for consumption levels for non-commercial (recreational or locally-caught) fish.

Response to the article was swift: Newspapers and electronic media across Canada picked up the story and within days, grocery stores across the country were reporting decreases (anywhere from 20% to 70%) in the sales of farmed salmon (Salmon Report, 2004; Salmon Sales, 2004; Bad Fish, 2004). Stores and fine-dining restaurants increased the profile of their wild salmon selections. This decrease in farmed salmon's popularity was bad news for Canadian fish farmers in provinces like British Columbia and New Brunswick, who had recently contended with significant financial losses due to disease outbreaks in their fish as well as falling prices across the global markets (Statistics Canada, 2005).

By 12 January 2004, as consumers were exercising their choices at grocery stores and restaurants, officials from the Canadian Food Inspection Agency (CFIA) and Health Canada were stating that salmon was still safe to eat at the levels of contamination found in the Hites report. These agencies did not dispute the levels of toxins found in the fish, but rather emphasized that the levels were still below Canada's maximum level of contamination: "According to the CFIA, there are no concerns over eating farmed salmon…especially in regard to contaminants. We feel the product is safe" (Bouzane, 2004). Health Canada's news release recommended that Canadians continue to eat farmed salmon, emphasizing that this food is a good source of healthy oils (Health Canada, 2004b).

Fish farmers around the globe fought the Hites report with their own press releases heralding the continued benefits of farmed fish for a healthy diet and dismissing the study's recommendations. The organization "Salmon of the Americas" (2003) even developed a press kit for retail outlets that provided hand-outs and other materials for consumers concerned about the issue. Pro-farming agencies such as Positive Aquaculture Awareness (PAA) accused the report of being misinterpreted by activists, even though the Hites article itself actually made the recommendations about the number of meals that people could safely consume ("Activists Use," 2004). Salmon farming groups were quick to respond to the bad press by extolling the heart-healthy virtues of eating salmon. These groups' arguments focused on the message that not eating farmed salmon would be more detrimental to people's health from a nutritional point of view than eating salmon that had low levels of contamination with PCBs and other contaminants. This risk/benefit message further complicated the issue for consumers. Farmed salmon is generally cheaper and more available year round than wild salmon, making it an easy

and healthy protein source. Should consumers stop purchasing this product? To this charge one of the authors, David Carpenter, responded that their study didn't suggest that people shouldn't eat farmed salmon, but rather that they should reduce the amount of farmed salmon that they eat until contamination levels decreased (Pianin, 2004). However, how consumers might find out when levels were decreasing was not clear, particularly when government agencies were stating that salmon was currently safe to eat.

The controversy over farmed salmon should not have surprised the government or the fish farming industry, since the Hites study was not the first to find chemical contaminants in farmed salmon. Three previous studies, all published in scientific journals in 2002, had also reported elevated pollutants in farmed fish compared to wild salmon, although those studies had been conducted with relatively few fish samples (Easton and Luszniak, 2002; Jacobs *et al.*, 2002a, 2002b). These studies formed the basis of activist campaigns against farmed salmon by U. S. organizations such as the Environmental Working Group (2006). The Hites study was the most comprehensive so far, testing over 200 pounds of fish tissues, and these results confirmed what earlier researchers had suggested about contamination levels. The Hites report was also not new information for the Canadian government agencies responsible for farmed salmon. In fact, Health Canada has been monitoring the levels of PCBs in retail foods yearly since 1992. Within these reports, fish samples in general (marine and freshwater) have consistently had higher levels of PCBs than most other food products (Health Canada, 2003). Additionally, the Canadian Food Inspection Agency (CFIA) routinely monitors contaminant levels in both fish and fish feed (Health Canada, 2001). Scientists in these agencies acknowledge that the numbers in the Hites report are similar to those of their own, in-house programs (personal conversation, Glen McGregor, 7 May 2004).

So, if the science is sound and the government agencies responsible for the health and safety of food in Canada are in agreement with the science on farmed salmon, then why were there conflicting messages about the safety of consuming farmed salmon? The difference in these risk management messages centre on the way that "acceptable levels" of toxins in food are determined. The discrepancy between Health Canada's safety message about farmed salmon and that from the Hites report stems from the different approaches taken to the assessment of human health risks. The Hites study used the U.S. EPA's method to assess risk and determine a safe consumption level. This approach differs somewhat from how acceptable food residue levels are determined by Health Canada and the U.S. Food and Drug Administration (U.S. FDA). The U.S. EPA method of determining safe fish consumption is used to develop advisories for recreational (locally caught) fish consumption in areas where there is environmental contamination. As of 2004, the US EPA had produced over 3000 such advisories for a range of fish species and contaminants. The U.S. EPA risk assessment approach determines the number of fish meals that can be safely eaten per month that will not exceed a lifetime (70-year) cancer risk of 1 in 100,000. Each

advisory is specific to a fish and contamination problem. The U.S. EPA's fish advisories clearly state how much of a certain type of fish can be eaten and also provides recommendations for groups of people such as pregnant women or infants who may be more at risk than the general population.

Health Canada's approach to setting a safe level of PCBs intake is based, in part, on a total diet approach. Health Canada examines both the benefits and risks from foods as well as looking at contaminants and average consumption levels. Maximum levels of contaminants are set for food groups rather than for specific foods like salmon. Health Canada had set its guideline for PCBs in fish at two parts per million (Health Canada, 2004b; these maximum levels are currently under review). This is the level that is also used by the U.S. FDA. Comparing the results from the Hites report to Health Canada's maximum level at the time, the results indicated that the level of PCBs found in farmed salmon was below the 2 ppm regulatory guideline.

Yet, regardless of the assurance by Health Canada and other governmental food regulatory agencies, salmon sales decreased both domestically and around the globe (Norwegian Salmon, 2004). This drop is sales provide evidence that the Hites report had captured the public's attention and that government assurances about the safety of farmed salmon were not working. Why? At its fundamental level, this debate about PCBs in farmed salmon is a product and a problem of risk communication. What was so compelling about Hites study was the clear and prescriptive narrative that told consumers how much and which type of fish they could safely consume. Newspaper reports across North American re-created these data in either text or graphical formats; in these forms they represented an actionable message that people could use to help reduce their exposure to a known toxicant. Additionally, the U.S. EPA's methodology, used by the Hites report, is also very clearly described and is available in detail on websites and in print publications that are geared to the general public. These documents include information about the assumptions that went into developing risk estimates, including portion sizes and body weights.

By way of contrast, Health Canada's response to the Hites report, dated 12 January 2004, stated: "Based on Health Canada's risk assessment, consuming farmed salmon does not pose a health risk to consumers" (Health Canada, 2004a). Nowhere in the press release or in supporting links and documents does Health Canada indicate *how* it determined that farmed salmon was safe, nor is there readily available information on how much salmon a person could eat that would keep them under the 2 ppm maximum level. Health Canada's press release was essentially stating, "Trust us, farmed salmon is safe," without offering an overview of what safe levels of consumption were or how the safety levels were derived. This paternalistic approach is contrary to much of the advice generated by risk communication research (Sandman, 2001). The effectiveness of the Hites report lay, in part, in its clear message and its prescriptive approach to personal risk management: Consumers were given information about the risk, the

approach used, and what options they had to manage their risk. Health Canada's message did not couch its risk/safety message in this manner, nor did it provide consumers with a basic understanding of how its "maximum level" was derived. As a result, Health Canada's safety message was much less resonant with consumers than the recommendations from the Hites study.

Beyond the issue of paternalism, Health Canada's farmed salmon safety message also suffered from the scope of the Canadian government's risk communication efforts, which has, to date, not been very broad. Historically, Health Canada has not aggressively disseminated risk information to the public and there has been insufficient work done to understand the Canadian public's perception of risks (see Krewski *et al.*, 1995a, 1995b). As a result, Canadian consumers are not used to engaging with the government regarding these types of risk issues. This lack of communication can lead to problems of trust and may not give the public much confidence that the government is managing risks in a way that reflect their priorities. As authors such as Slovic (1993) suggest, trust is a key component for successful risk communication. This problem has not gone unnoticed in government, and very recently, in May of 2006, Health Canada added new Risk Communication tools to its website. These tools range from urgent warnings to information updates that help inform Canadians about potential health risks (Health Canada, 2006b). Whether or not these advisories will help to engage Canadians in discussing risk issues with policy makers remains to be seen. Citizens want to be involved, or at least have the opportunity to be involved, in decisions about risks to which they are involuntarily exposed (Foster, n.d.). Simply adding more warnings without addressing the problems of transparency and allowing for public input or comment may not be what Canadians need to engage in risk debates with the government.

The fish farming controversy also clearly illustrates the problems that result from not anticipating risk controversies. Both the Canadian government and the fish farming industry were put on the defensive regarding the Hites report, even though both acknowledge having known for some time that there are relatively high (compared to other food groups) levels of PCBs in fish tissues. This problem could have proactively been acknowledged and contextualized for consumers (i.e. explaining dietary contributions of PCBs from all foods, discussing the evidence for PCB toxicity, etc.). Public concern about PCBs is not a new phenomenon, and exposure to these chemicals is well known to increase public anxiety. The government and fish farmers' failure to appropriately address the problem of toxins in fish tissues left them open to having others set the risk agenda for them. The public's reaction to the Hites report may have been different had the government or the industry had a history of communicating with consumers and health professionals about the levels of contamination in Canadian fish products and the implications of this for public health.

Other, peripheral issues also helped to ignite ire in the farmed salmon risk debate. Beyond the government's lack of ongoing and engaging risk communication, the farmed fish industry's profile aggravated the PCB controversy. Problems of disease outbreaks such as sea lice (Krkosek *et al.*, 2005) and Infectious Hematopoietic Necrosis Virus (IHNV), which require massive culls of farmed fish, as well as issues of environmental contamination (Debruyn *et al.*, 2006), have been on the Canadian news agenda for quite some time and have resulted in a generally poor media climate for the aquaculture industry. Additionally, unlike cattle ranchers, fish farmers cannot necessarily rely upon grass-roots public support during difficult times, because many of the salmon farms are in relatively remote coastal areas and are foreign-owned operations. Challenges to the local wild salmon also generate opposition both from First Nations people and from those who based their livelihood on the more established ocean-caught salmon industry.

Ultimately, the salmon farming industry has had numerous strikes against it, the majority of which have captured media attention both in Canada and around the world. In an already poor public relations environment, the news that farmed fish may also be bad for human health may convince consumers to no longer buy farmed products. Given that other options exist, such as buying the somewhat more expensive wild salmon, or buying other fish species, it is relatively straightforward for consumers to register their discontent with the industry. Even before the Hites report, fine-dining establishments and high profile restaurants on the west coast of Canada had already made the switch from farmed to wild salmon due to the perceived negative public reaction to farmed salmon.

The Canadian government's relationship with the fish farming industry may also detract from its ability to send safety messages to the public concerning farmed fish products. Across Canada, aquaculture has grown at an annual rate of 19% between 1996–2001 with support from both provincial and federal government bodies. However, some groups have criticized the government for being too close to the fish farming industry, and one British Columbia fisheries minister resigned as a result of a police investigation of his handling of the aquaculture file in 2001 (Jang, 2003). Suspected political interference with fish farming organizations, particularly in the province of British Columbia, has made national headlines (Lee, 2004). Organizations such as the David Suzuki Foundation have criticized the federal Department of Fisheries and Oceans for promoting fish farming at the expense of the environment that they are entrusted to protect (Peterson *et al.*, 2005). Such interaction between the government and the industry makes it harder for consumers to trust that the government is prioritizing human and environmental health over the rapid development of this industry.

The story of the farmed salmon controversy illustrates the problems that emerge when communication failures exist between the government and the public; it is also a story about the hazards encountered by companies that do

not openly address the problems represented by their industry's development. Fish farming has evolved in Canada with a fairly small amount of public consultation or involvement while being supported and promoted by government agencies and off-shore companies. Scientists and environmental groups have raised a broad spectrum of concerns, many which have not been adequately addressed by those responsible for regulating aquaculture or human health. Such an environment does not breed trust or allow citizens to be confident that risk management decisions are being made in their best interests. This very public debate also illustrates the limitations of risk assessment and the confusion that arises from not clearly outlining how "safe" levels are determined. Although such processes are often complex and filled with uncertainty and assumptions, there is little excuse for the lack of transparency in how regulatory bodies approach and assess risk.

Conclusion

Quite different dimensions of the complex challenges in food risk communication are revealed by the two Canadian cases reported here. In the case of BSE, the sudden appearance of a "dread-risk" source did not lead to a crisis of consumer confidence or cause a fall in beef consumption. There was still major risk communication failures of a different sort, however: A failure of federal authorities to properly assess and communicate the risk of BSE and to a specific group within the Canadian public, namely, small independent beef producers. Whereas this would normally be classified as an "economic risk," such risks also have social and health consequences – in this case, for farm families. There is much anecdotal evidence about adverse health consequences and other outcomes, such as suicide, among farm families, resulting from the sudden collapse of the export market for beef and the decline in farm incomes (even after offsetting by government support payments). However, to date it has been difficult to document these important impacts; the report entitled "Farmers, Farm Workers and Work-Related Stress," commissioned by the U.K. Health and Safety Executive and released in 2005, is one of the first to do so, and more are needed (Health and Safety Executive, 2005).

In this case the risk communications failed to accurately express the nature and scope of the risk as it had been evaluated by government officials in technical documentation (some of which was never publicly released). We have tried to demonstrate that, in fact, the complex statistical manipulations served as a smokescreen behind which was hidden the true – catastrophic – risk, namely, that the discovery of even a single case of BSE in the Canadian herd would have "extreme" consequences for the entire group of small, independent beef producers. They were never told, in plain and simple language, by those whose responsibility it was to assess this risk, what was facing them.

In the case of farmed salmon, a high-profile scientific study on chemical contaminants led to a significant adverse reaction on the part of

consumers – who were then blamed by some for not understanding that the numbers were non-threatening. They were also blamed for not understanding that the risk/risk or risk/benefit trade-off (risks posed by the contaminants vs. health benefits from eating fatty fish) was overwhelming in favour of continued fish consumption. However, our study shows that the contaminant numbers are open to differences in interpretation among government agencies, and that understanding the level of risk is no simple business.

In this case the farmed salmon industry should have been alerted to the issue by a series of studies in 2002 that indicate the presence of contaminants in farmed fish tissues. The fish farming industry should have acted years ago to ensure that the public was provided with reliable resources for understanding the nature of chemical contaminants in fish and the risk assessment methodologies used for determining safe levels of consumption. (At the moment the only user-friendly information, replete with good graphics and references to the scientific studies, is provided by environmental organizations.) A template has been developed for a web-based public information resource, operated by a disinterested third party, to assist the public in understanding complex scientific information on issues of concern (Emcom, n.d.). The farmed salmon industry would be wise to move in a similar direction, for there are surely more studies such as the one conducted by Hites *et al.* (2004) now being done.

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Appendix A

The point being made can only be fully appreciated if shown the full context in which the short quoted sentence appears (CFIA, 2002a):

> The mathematical model used to estimate the probability of at least one infection by oral transmission for n imported animals is as follows:
>
> $$P(I\$1) = 1 - ((1 - f_1) + f_1^*((1 - f_2)^*\big((1 - f_3) + f_3^*\big((1 - f_4) + f_4^*(1 - f_5)\big)\big) + f_2^*\big((1 - f_6) + f_6^*\big((1 - f_7) + f_7^*(1 - f_8)\big)\big)\big)\big)^n$$
>
> The estimated probability of at least one infection of BSE occurring prior to 1997 was 7.3×10^{-3} with a 95% confidence level of 2.0×10^{-2} (Figure 5). This estimate was based on the expected number of BSE-infected animals that may have been imported, then were slaughtered or died, with their carcasses subsequently rendered between 1979 and 1997. Therefore, the likelihood of establishment of BSE in Canada was negligible. If BSE was introduced, the consequences would be extreme.

> The sensitivity analysis (Figure 6) identified the most critical inputs for the model. With the rank order correlation sensitivity analysis, the coefficient is calculated between the selected output variable and the samples for each of the input distributions. The higher the correlation between the input and the output, the more significant the input is in determining the output's value. The tornado graph (Figure 6) indicates that the "age in months," showing the longest bar and a positive coefficient of 0.368, was the most important input for the estimate of the probability of at least one infection. "Pf1," which represented the function assimilating the prevalence of infection by country and year of birth, was second in importance with a positive coefficient of 0.76. The input variable "ncoid50," representing the number of cattle oral ID_{50}s, revealed a correlation coefficient of 0.023.

To the best of our knowledge, the key sentence – "If BSE was introduced, the consequences would be extreme" – occurs nowhere else in this long Risk Estimation document itself or in any other public communications by the Agency either then or later.