CONTAMINATED SALMON *and the* Public's Trust

SAMUEL N. LUOMA

Differences in data choices have led to conflicting interpretations about an important consumer issue.

SAMUEL N. LUOMA
U.S. GEOLOGICAL SURVEY AND THE NATURAL HISTORY MUSEUM (U.K.)
RAGNAR E. LÖFSTEDT
UNIVERSITY OF LONDON, KING'S COLLEGE

Scientific uncertainties often make it difficult for environmental policy makers to determine how to communicate risks to the public. A constructive, holistic, multisectoral dialogue about an issue can improve understanding of uncertainties from different perspectives and clarify options for risk communication. Many environmental issues could benefit from explicit promotion of such a dialogue. When issues are complex, unconstructive advocacy, narrow focus, and exclusion of selected parties from decision making can erode public trust in science and lead to cynicism about the policies of government and the private sector.

In this article, we use as an example, the ongoing discussion about the balance of risks when choosing between farmed and wild salmon as a source of human nutrition. We submit that better justified decisions about "green" choices in food products (particularly fish) may be a benefit of pursuing the type of dialogue described above.

Growing demand for fish

The health benefits of eating fish are increasingly recognized by the public. Salmon have very high concentrations of n-3 polyunsaturated fatty acids and thus are one of the most heart-healthy of the commercially available fish species. But salmon fisheries, like many of our wild fish stocks, are difficult to manage. Atlantic salmon stocks throughout the world were at a historic low in 2004 (*1*). Once-strong salmon fisheries in the western U.S. now also have many diminishing populations. To provide adequate conservation of weak stocks, management plans are forgoing some harvestable surplus of stronger stocks. For example, in 2006, the northern California chinook salmon fishing industry was largely shut down to prevent extinction of a stock victimized by a controversy over water policy in the Klamath River basin to the north (*2*).

Aquaculture is one of the fastest growing areas of food production, supplementing harvest as a source of healthy protein. Salmon farming, in particular, provided ~700,000 tons of fish from the North Atlantic basin alone in 2002 (*3*). In the absence of appropriate safeguards, aquaculture raises important environmental issues (*4*). Better practices can reduce such threats, although implementation of best practice is far from universal (*3*). Farmed salmon help fulfill a growing global demand for fish, but is it sustainable to obtain protein from an upper-trophic-level farmed fish? Or is that question too simple?

Rankings of sustainable fisheries are a popular way to help consumers make environmentally friendly choices about fish protein. A few wild-salmon fisheries (e.g., from Alaska) are cited as sustainable in most lists. In general, farmed salmon are deemed an unsustainable food source (*5*), when considered (aquaculture is excluded from consideration in the popular Marine Stewardship Council certification scheme). Strategies exist to compare salmon farming practices across the world (*3*), but this information is not included in advice about sustainable fisheries.

Adding complexity to the sustainability debate, farmed salmon were cited in 2004 (*6*, *7*) as more contaminated with health-threatening pollutants—in particular PCBs/dioxins, brominated flame retardants, and pesticides—than wild salmon. These articles promoted strict consumption restriction guidelines (*8*, *9*).

Conflicting interpretations

The identification of chemical contamination in farmed salmon had an immediate impact in the press (as judged by worldwide news coverage), on the public (reduced sales of farmed salmon were reported), and on perceptions of the state of the science. However, no study, even one that is large and well done, can answer every scientific question, and this one left some important questions unanswered.

For example, the charge that "contaminant levels were about an order of magnitude higher in farmed and market samples than in wild Pacific salmon" (*9*) was consistent with the specific data used in the study (the last three words were crucial to the validity of the conclusion). But the broader communication of risk was more questionable. The message that reached consumers was that wild salmon are safer to eat than farmed salmon. A panel of experts convened by the European Food Safety Authority to address the issue reached a different (but less publicized) conclusion: there is not enough difference between contamination of wild and farmed salmon to differentiate risks to human health (*10*). The differences in conclusions were the result of differences in choices of data (Table 1). Conflicting interpretations about an important consumer issue add to the growing erosion of public trust in advice from experts (*11*), and wild versus farmed salmon is an excellent example of such a conflict.

Conflicting interpretations about an important consumer issue add to the growing erosion of public trust in advice from experts.

The risk advisories in the original studies conclude: "To achieve a cancer risk of 1×10^{-5}, consumption of farmed salmon must be effectively eliminated" (*8*). Quantitatively, this is translated into advice against consumption of farmed salmon from the North Sea more than once in every 4 months and the least contaminated farmed salmon (from Alaska) more than once or twice per month (*9*). This is followed by a surprising conclusion: "Even wild Pacific salmon evoke consumption advisories based upon U.S. methods . . . [such] cancer-based advisories indicate the extent to which we have polluted even the oceans."

The dramatic conclusions about health risks are based on the EPA models, which assume linear correlations between cancer and exposure and use upper-confidence-interval estimates to ensure the most cautious estimates of risk (*12*). Different methodologies result in advisory limits that vary widely among agencies within the U.S., member states of the EU, and international bodies like the World Health Organization. But the degree to which these jurisdictions contradict each other is rarely appreciated. For example, EPA risk assessments would apparently restrict consumption of all salmon in the world (wild or farmed). But even the most contaminated farmed salmon did not exceed the most widely used international advisory limits—those from the U.S. Food and Drug Administration and the European Food Safety Authority. Consumption advice on farmed salmon can range from 0.25 meals per month by EPA standards to perhaps 6 meals per month by internationally accepted risk standards. Foran et al. (*8*) conclude that "divergent consumption recommendations that result from inconsistent risk assessment and exposure reduction methods exacerbate consumer confusion." But they did not quantify the outcomes of alternative analyses, discuss uncertainties in the approaches, or explain why other advisories might differ so widely from theirs.

Relative risk

The contradictions in the scientific conclusions and the risk analysis become more serious when the issue of relative risk is considered. Cohen et al. (*13*) identified risk trade-offs in public advisories about fish consumption, suggesting it is important to balance risk from contaminants against risk to other aspects of health suffered from not eating fish and substituting less healthy foods. They note, when analyzing risk–benefits of mercury advisories: "Although high compliance with recommended fish consumption patterns can improve public health, unintended shifts in consumption can result in public health losses. Risk managers should investigate and carefully consider how populations will respond to interventions, how those responses will influence nutrient intake and contaminant exposure, and how these changes will affect aggregate public health." A contentious dialogue followed the publication of the salmon contamination papers (*14*, *15*), mostly because the risk analysis for salmon did not consider a balance of risks (*14*). A careful consideration of the net health outcomes was lost (especially in the less formal dialogue) amid accusations of economic/political motivations and ties to the fish-farming industry.

A policy recommending that the public avoid consumption of farmed salmon and switch to wild salmon (*9*) has important implications for wild fisheries. Can Alaskan and British Columbian fisheries sustain the harvest a global demand for their products is creating? How does the relative risk to wild salmon from fish farming compare with the risk from the expanded harvest that increased demand could trigger? "Green" certification of a fish species might benefit from an integrated consideration of the sustainability of both fish harvest and fish farming for a specific product; that would include consideration of health benefits, health risks, ecological risks, and harvesting risks. The academic community might play a role in development of criteria to guide this more complex, but more holistic, analysis.

The contaminated-salmon issue thus brings out several points that are typical of our increasingly complex environmental dilemmas. Advice to consumers requires recognizing multiple uncertainties in a politically charged climate. Some believe the public can sort out the "truth" if each side advocates its best case. Sectoral allegiance (do you agree with industry, NGO, government, or the academic?) is deemed by some to be sufficient evidence for who presents the dispassionate and, therefore, correct analysis. The alternative view is that progress is unlikely on complex environmental issues if dialogue breaks down into a politically charged advocacy debate or if important interest groups are excluded (*16*, *17*). Such a breakdown characterizes where we are in the dialogue about health risks from consumption of salmon. Both a rational dialogue and a sense of urgency are necessary if consumers are to expect progress in addressing the obvious contradictions.

TABLE 1

Dioxins + furans and PCB concentrations in wild and farmed salmon from different locations as reported by different authors

The general conclusion that farmed salmon are more contaminated than wild salmon (*8*, *9*) heavily rests upon restricting the definition of wild salmon to Alaskan and British Columbia stocks. Position in the food web also makes a difference. Concentrations are widely different among populations of wild salmon. No data exist for many commercially exploited populations.

Location	Mean dioxins + furans (ng TEQ/kg fresh wt)	PCBs (ng/g fresh wt)
EU farmed[a]	0.50	—
North Sea farmed[b]	0.6–0.8	40–50
North America farmed[b]	0.1–0.5	20–40
British Columbia wild chinook	0.1–0.2	10–20
Alaska wild chinook	<0.2	<10
Washington State wild[c]	—	74.2
Baltic wild[a]	7.23	—

[a]Ref. 10.
[b]Ref. 6.
[c]Ref. 23.

Multisectoral dialogue

A challenge for the "second environmental movement" (*18*) is to move beyond diagnosing maximum risks and leaving the solutions to others (*19*). As Schnoor notes, an important part of enlightened environmentalism might be recognition that constructive international dialogue is in the best interest of academic, business, and NGO communities (*18*). In the case of the salmon issue, such a dialogue can be aimed, for example, at improving criteria for green choices.

A constructive dialogue does not necessarily benefit from sector-specific advocacy, but it must include all sectors as partners in an open discussion. The scientific community has shown many times that fair, multisectoral dialogue is possible (*20*); it can be proactively constructive without dictating policy, and it can achieve support from multiple interests (*20*). Discussions of issues surrounding fish farming, safety of fish products, and choices of sustainable fisheries may benefit from that experience.

Public trust in science is the greatest resource at stake in the dialogue about complicated risks (*11*, *17*). Trust develops when the public recognizes fairness, competence, and efficiency in an enterprise (*21*). Although there is a legitimate role for advocacy in some arenas, a debate among scientists who advocate isolated positions does not bring out a sense of fairness, it rarely demonstrates competence, and it is hardly ever efficient. When discussions of the salmon issues degenerated to rancorous debate among advocates (*14*, *15*), confusion and rejection of all rational dialogue by both the public and policy leaders was to be expected (*16*).

Do we need to reconsider criteria for scientific publication in light of the public trust issues? The standards for publishing basic science have raised trust in that enterprise. In evaluating a scientific article, the focus is on the rigor of the methodologies and the logic. How risks are communicated is a less common consideration. This does not mean pulling punches, science by consensus, or ignoring proclivity for type II error in environmental analyses. The best science, and perhaps the best communication, might be judged by how well it considers the full scope of the relevant literature and the complete scope of the issue.

Progress is unlikely on complex environmental issues if dialogue breaks down into a politically charged advocacy debate.

Disagreement is a necessary part of science and risk communication. But trust is better served by a focus on why disagreements exist rather than who is right. Advocacy has a role. But credibility grows faster, and incremental solutions appear, when the scientific discourse frames and reframes the agenda for a problem, building from what can be agreed upon rather than trying to resolve disagreements (*16*). Recognition of complexity in environmental issues might inspire cynicism in some critics, but it serves better than oversimplification in helping the public and policy makers see their choices (*22*). We probably do not fully understand all the ingredients of a constructive science dialogue, especially those that optimally generate public trust and effective policy. The salmon issue is an example of the need for improving that understanding.

Samuel N. Luoma is a senior research scientist at the U.S. Geological Survey and a scientific associate and Fulbright Scholar at the Natural History Museum (U.K.). Ragnar E. Löfstedt is director of the King's Centre for Risk Management at the University of London, King's College. Address correspondence about this article to Luoma at snluoma@usgs.gov.

Acknowledgment

This work was partially supported by a W. J. Fulbright Distinguished Scholar Award to SNL.

References

(1) Atlantic Wild Salmon Stocks at Historic Low, www.cbc.ca/story/canada/national/2004/06/03/salmon040603.html.
(2) Levy, S. Turbulence in the Klamath River Basin. *Bioscience* **2003**, *53*, 315.
(3) Porter, G. *Protecting Wild Atlantic Salmon from Impacts of Salmon Aquaculture: A Country by Country Progress Report*; World Wildlife Fund: Washington, DC, 2003; www.worldwildlife.org/oceans/pdfs/oslorespprogress.pdf.
(4) Goldburg, R. J.; Elliott, M. S.; Naylor, R. L. *Marine Aquaculture in the United States. Environmental Impacts and Policy Options*; Pew Oceans Commission: Arlington, VA, 2001.
(5) Best & Worst Seafood Choices, www.oceansalive.org/eat.cfm?subnav=bestandworst.
(6) Hites, R. A.; et al. Global Assessment of Organic Contaminants in Farmed Salmon. *Science* **2004**, *303*, 226–229.
(7) Hites, R. A.; et al. Global Assessment of Polybrominated Diphenyl Ethers in Farmed and Wild Salmon. *Environ. Sci. Technol.* **2004**, *38*, 4945–4949.
(8) Foran, J. A.; et al. Risk-Based Consumption Advice for Farmed Atlantic and Wild Pacific Salmon Contaminated with Dioxins and Dioxin-Like Compounds. *Environ. Health Perspect.* **2005**, *113*, 552–556.
(9) Huang, X.; et al. Consumption Advisories for Salmon Based on Risk of Cancer and Noncancer Health Effects. *Environ. Res.* **2006**, *101*, 263–274.
(10) *Opinion of the CONTAM Panel Related to the Safety Assessment of Wild and Farmed Fish*; European Food Safety Authority: Brussels; www.efsa.europa.eu/en/science/contam/contam_opinions/1007.html.
(11) Lofstedt, *R. E. Risk Management in Post Trust Societies*; Palgrave/MacMillan: Basingstoke, U.K., 2005.
(12) Verkasalo, P.; et al. Risk–Benefit Analysis of Eating Farmed Salmon. *Science* **2004**, *305*, 476.
(13) Cohen, J. T.; et al. A Quantitative Risk–Benefit Analysis of Changes in Population Fish Consumption. *Am. J. Prev. Med.* **2005**, *29*, 325–333.
(14) Rembold, C. M.; et al. The Health Benefits of Eating Salmon. *Science* **2004**, *305*, 475–478.
(15) Hardy, M. Comment on "Global Assessment of Polybrominated Diphenyl Ethers in Farmed and Wild Salmon". *Environ. Sci. Technol.* **2005**, *39*, 377–378.
(16) Schneider, A. L.; Ingram, H. *Policy Design for Democracy*; University Press of Kansas: Lawrence, KS, 1997.
(17) Pharr, S. D.; Putnam, R. D. *Disaffected Democracies: What's Troubling the Trilateral Countries*? Princeton University Press: Princeton, NJ, 2000.
(18) Schnoor, J. L. Starting Over: A Second Environmental Movement. *Environ. Sci. Technol.* **2002**, *36*, 273A.
(19) Boesch, D. F. Challenges and Opportunities for Science in Reducing Nutrient Over-Enrichment of Coastal Ecosystems. *Estuaries* **2002**, *25*, 886–905.
(20) Jacobs, K.L.; Luoma, S. N.; Taylor, K. A. CalFed, An Experiment in Science and Decisionmaking. *Environment* **2002**, *45*, 30–41.
(21) Renn, O.; Levine, D. Credibility and Trust in Risk Communication. In *Communicating Risks to the Public: International Perspectives*. Kasperson, R. E., Stallen, P. J. M., Eds. Kluwer: Amsterdam, 1991; pp 175–218.
(22) Morgan, M. G.; et al. Communicating Risk to the Public. First, Learn What People Know and Believe. *Environ. Sci. Technol.* **1992**, *26*, 2048–2056.
(23) O'Neill, S. M.; West, J. E.; Hoeman, J. C. Spatial Trends in the Concentration of Polychlorinated Biphenyls (PCBs) in Chinook (*Oncorhynchus tshawytscha*) and Coho Salmon (*O. kisutch*) in Puget Sound and Factors Affecting PCB Accumulation: Results from the Puget Sound Monitoring Program. In *Puget Sound Research 1998 Proceedings*; Strickland, E. R., Ed. Puget Sound Water Quality Action Team: Seattle; pp 312–328.