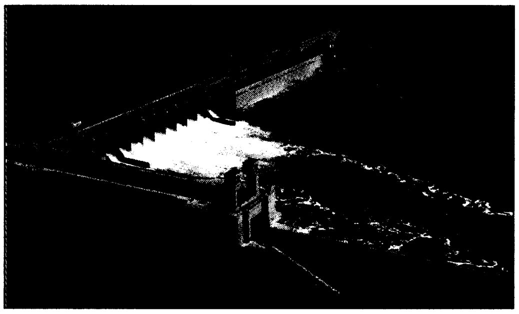
came very complicated. The PATH was successful in that it distilled the uncertainty about causes of the decline of Snake River Chinook salmon to a small set of management decisions.

The Cumulative Risk Initiative (CRI), created by the National Marine Fisheries Service (NMFS), diverted attention away from the impact of dams to mortality at other life-cycle stages. Taking spring/summer Chinook as an example, the CRI team identified the first year of freshwater residence as a promising stage for decreasing mortality, as Mann and Plummer note. However, first-year survival rates (before migration down river) have not declined since the construction of the Snake River dams; hence, there is little scope for increasing survival during this stage (*2*).

The real losers in this process are the salmon. Most of the incremental solutions to increasing dam-passage survival have been implemented, but they cannot provide sufficient increases in survival to meet standards determined to be necessary for survival and recovery of the species (jeopardy standards), which were specified by the NMFS in 1995. For this reason, the essential decision is reduced to choosing between dam breaching and the status quo. By deferring action for 8 years, the NMFS plan increases the extinction risk and the cost of recovery. The life-cycle model shows that delaying action decreases the probability of meeting the jeopardy standards. On the basis of the most recent escapement counts, a 7.5-fold increase in survival is necessary to meet the 24-year survival standard (one of the jeopardy standards). The only measure with any chance of success is to eliminate mortality of the smolts in the reservoirs and mortality downstream of the last dam, which may be related to the presence of dams and/or transportation effects.



To breach or not to breach: that is—or is it?—the question.

CREDIT: U.S. ARMY CORPS OF ENGINEERS

We agree that the debate and decision on how to recover depleted stocks of Columbia River salmon has become political and legal. In reference to global warming, Vice President Al Gore wrote, "Research in lieu of action is unconscionable....[A] choice to 'do nothing' in response to the mounting evidence is actually a choice to continue and even accelerate the reckless environmental destruction that is creating the catastrophe at hand" (*3*). Can science rescue salmon? No, but scientists can study salmon to death.

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3. A. Gore, *Earth in the Balance* (Houghton, Boston, MA, 1992), p. 37.

Response

In their letter, Collie and the other members of the Scientific Review Panel say that PATH "distilled the uncertainty about causes of the decline of Snake River Chinook salmon to a small set of management decisions." Indeed, "the essential decision [for saving Snake River salmon] is reduced to choosing between dam breaching and the status quo."

As the report by Kareiva *et al.* in this issue (p. 977) makes clear, however, the decision to save Snake River Chinook is more complicated than a simple choice between breaching the dams and the status quo. And in recent scientific documents, some members of the Scientific Review Panel themselves drew strikingly different conclusions. During his tenure on the panel, Walters wrote, "I no longer trust your [that is, the PATH] assessments about the range of uncertainty in recovery predictions under alternative policies, [and] in particular I do not trust your finding that there is a very high long-term recovery probability under the dam removal options (where the passage models become the dominant factor causing differences among policies in predicted performance). I suspect that after some reflection, you are going to have to admit considerably greater uncertainty about whether even these extreme measures will do the job" (*1*).

Saila and Carpenter expressed similar reservations during their tenure on the panel. Indeed, Saila criticized PATH for paying "insufficient attention" to "the treatment of uncertainties associated with model inputs" (*2*)—that is, failing to recognize how uncertainties in the data would affect the validity of its predictions. (The panel's reviews can be found at http://www.efw.bpa.gov/Environment/PATH)

In researching our article, every scientist we spoke with viewed PATH as a valued component of the scientific work that supports salmon policy-making in the Pacific Northwest. But many researchers do not believe that the PATH work conclusively narrows the policy questions to dam breaching. Nor would it be accurate to characterize the contrasting CRI results, as Collie *et al.* do, as simply "divert[ing] attention away from the impact of dams." By bringing a different scientific perspective to the problem, the CRI work, also produced by a blue-ribbon group, focuses attention on the magnitude of that impact, in absolute terms and relative to other recovery measures. The debate over these measures may be "political and legal," as Collie *et al.* note, but it is also scientific.

It is possible to "study the salmon to death," as Collie *et al.* put it. But the argument of the scientists who disagree with them is that it is also possible to advocate the fish to death, if that advocacy forecloses options that are just as beneficial as those from dam breaching—and more easily attained.

Charles C. Mann
Mark L. Plummer

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No Longer a Source of Dioxin

In the News of the Week article "Just how bad is dioxin?" (16 June, p. 1941) about the Environmental Protection Agency's (EPA) reassessment of the risks of dioxin, Jocelyn Kaiser suggests that one of the major sources of this toxic chemical is the paper bleaching process.

Paper bleaching with elemental chlorine did generate small amounts of dioxin as a by-product. The discovery of this relation, which was the result of an industry-EPA cooperative sampling effort in the mid-1980s, prompted responsible companies in the industry to change their bleaching processes, well before EPA's recent "cluster" regulations. These regulations require no detection of dioxin at levels of parts per quadrillion measured in the bleach plant. In addition, research suggests that dioxin (tetracholordibenzodioxin) is not generated from alternative bleaching technologies now in use (*1*). Today, little if any dioxin is generated. Bleached paper mills are no longer a significant source as suggested in the article.

This is a case where industry has made a pollution-prevention achievement of great magnitude and has virtually eliminated dioxin from its processes.

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Clarifying the SF_5CF_3 Record

W. T. Sturges and colleagues report on the identification of SF_5CF_3 in the atmosphere and point out that this compound could be an important greenhouse gas (Reports, "A potent greenhouse gas identified in the atmosphere: SF_5CF_3," 28 Jul., p. 611). The identification is based on the mass spectrum of this compound, which the authors list as "68.995 (CF_3^+), 88.967 (SF_3^+), and 126.964 ($SF_5CF_3^+$)." This latter assignment is wrong: the ion at the mass-to-charge ratio (*m/z*) of 126.964 is due to SF_5^+. This mistake may be just a typographical error, but it could be misleading by suggesting that a molecular ion for this molecule has been observed, which it has not. Incidentally, contrary to the authors' statement, a library mass spectrum for SF_5CF_3 is available in the National Institute of Standards and Technology (NIST) Mass Spectral Library (version 1.6).

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Response

We thank Hites for noting the typographical error. Mass 126.964 is indeed attributable to the SF_5^+ ion, not $SF_5CF_3^+$ as stated in our report (*1*). The molecular ion is not formed. It is true that SF_5CF_3 now appears in the latest version of the NIST Mass Spectral Library (version 1.6), but this version was not supported on our particular instrument at the time of the study. We can, however, confirm an excellent match between the spectrum we obtained from the pure compound and that given in the updated NIST library (see the figure). We remain confident in our identification of SF_5CF_3 in the atmosphere, as is also illustrated in the figure.

Regarding the letter from Santoro of 3M, he suggests a plausible origin of SF_5CF_3 in the atmosphere, presumably from the electrochemical fluorination production of widely used intermediates and products such as trifluoromethanesulfonic ("triflic") acid and fluorosurfactants. This process has been in use since the late 1950s, which fits our observations of detectable SF_5CF_3 in air samples dating from the 1960s. What is not clear, however, is whether the amounts released by electrochemical fluorination can account for the year-on-year rise in emissions to a current rate of 270 metric tons per year. In the absence of actual emission data, the possibility of other sources cannot be ruled out. Efforts by private companies

Sturges *et al.* indicate in their report an uncertainty as to the origin of SF_5CF_3. We know that one source of this compound is as a by-product of the manufacture of certain 3M fluorochemicals.

The authors correctly suggest that concentrations of SF_5CF_3 detected in the atmosphere are so small as to be a minor contributor to overall radiative forcing. Despite this, they appropriately call attention to the prudence of limiting releases of SF_5CF_3. In fact, 3M had already implemented a comprehensive program to reduce all greenhouse gas emissions, including SF_5CF_3, from company operations. Since 1995, the company has reduced global greenhouse gas emissions by more than 40%, and additional reductions, on the order of 50% or more, are planned over the next 1 to 5 years.

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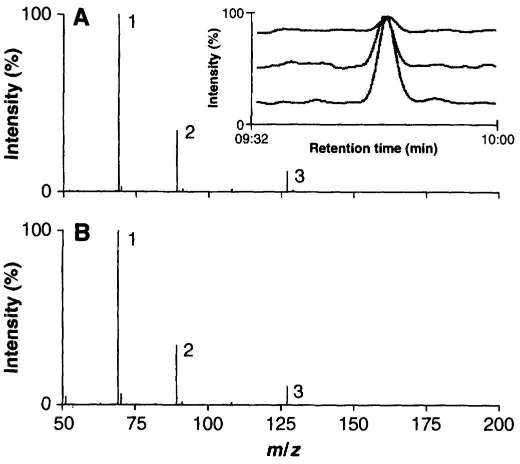

Mass spectrum (*m/z* 50 to 200) of SF_5CF_3. (**A**) Gas chromatography–mass spectrometry (GC-MS) measurements by this group (1) and (**B**) NIST Mass Spectral Library Version 1.6d entry 23164. The ions marked 1 to 3 correspond to CF_3^+, SF_3^+, and SF_5^+, respectively. The ion SF_4^+ (*m/z* 107.966) is also observed at low abundance. The inset shows the GC-MS analysis of 200 standard cubic centimeters per minute of "clean" ambient air [Colorado Mountains, collected in 1994 (*1*)] showing peaks of *m/z* corresponding to the same ions (1 to 3) in the traces from the bottom to top, respectively, at the retention time expected for SF_5CF_3.