

## ARTICLES



VIKTOR KOJEN

# A SKY FULL OF HOLES

## WHY THE OZONE LAYER IS TORN WORSE THAN EVER

**MARK DOWIE**

**P**enguins are dying in Antarctica, and that may signal a problem for us all. It also may be cause to ask whether the worldwide environmental establishment is afflicted with attention deficit disorder.

In these days of eco-realism, too many environmentalists, scientists and politicians tend to shift focus swiftly from one issue to another, pronouncing the first solved and considering the second fresher, more mediagenic. Ozone depletion is a case in point. Today, the breakdown of stratospheric ozone—a problem recently declared fixed—is being ignored, while the newer controversy of “climate change” launches a thousand conferences. But in fact, the peril of ozone

depletion, which is caused by humankind's release of chlorofluorocarbons (CFCs) and other chemicals into the atmosphere and which leads to the disintegration of the protective layer that shields life from cancer-causing ultraviolet waves, is demonstrably worse than conventional environmental wisdom holds. Moreover, the 1987 measures now agreed to by more than 150 nations to counter ozone depletion are inadequate to the task; smugglers in India and the former Soviet bloc are subverting global restrictions on ozone-depleting chemicals; and at the regulatory end, World Bank bureaucrats and Clinton Administration officials are ignoring troubling omens: lower-than-expected ozone values over the Northern Hemisphere, a disturbing connection between global warming and ozone depletion, and the mysterious death of those young penguins near the South Pole.

Normally, adult Adélie penguins spend a few hours foraging the icy waters off Antarctica and return to their nests before dark with a belly full of seafood, most of it to feed their young. During December 1994 (austral summer), penguins nesting at Bechervaise Island had to range as far as 200 miles offshore, and hunted for up to nine days nonstop. Most returned empty. All but ten of the 1,800 chicks hatched on the island that summer died of starvation.

Wildlife biologists and marine scientists are still baffled by the event, which repeated itself in two nearby rookeries but hasn't occurred since. "We have never seen anything like this before," declared Knowles Kerry, an Australian scientist based at a research station a few miles north of Bechervaise. There are several possible explanations. But the most intriguing and controversial thesis blames excessive ultraviolet B (UVB) radiation passing through the "ozone hole" over Antarctica and killing off phytoplankton, the basic food source of krill, which is the favored prey of Adélie penguins. If this is true, the penguins could be to us what canaries were to miners a century ago.

UVB penetration is the dreaded but inevitable consequence of stratospheric ozone depletion, a phenomenon theorized by Nobel laureates Sherwood Roland and Mario Molina in 1974, scorned by industrialists for a decade, then proven to be real by a continent-sized hole found in the ozone layer over Antarctica in 1985. Testy negotiations between developed and developing nations of the North and South led to the drafting in 1987 of the Montreal Protocol on Substances that Deplete the Ozone Layer, the world's most ambitious environmental treaty. The protocol and its amendments are regarded by scientists and diplomats as a triumph of human ecological diplomacy. And most regard its results as a success.

"The Montreal Protocol is working," brags the United Nations Environmental Program (UNEP). "Peak ozone depletion is now expected to occur during the next several years and the ozone layer is expected to recover in about fifty years," when the Antarctic hole closes up again. That assumption is shared by the Clinton Administration. Even greens have joined in the

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optimism. "I don't think a catastrophe is in the offing," says Michael Oppenheimer, an atmospheric scientist at the Environmental Defense Fund. He believes that "if it is implemented right, the Montreal Protocol will eventually lead to the healing of the ozone layer." And the media have bought into the euphoria.

"After 2000, Outlook for Ozone Layer Looks Good" read the front-page banner headline of *The Washington Post* three years ago. "Depleted Ozone May Begin Recovery Within Ten Years," the *Post* cheered recently after a National Oceanic and Atmospheric Administration (NOAA) report was issued announcing that some, though not all, atmospheric ozone-depleting chemicals were themselves in decline and that we would pass the peak destruction between 1997 and 1999. "Good news about the environment," chirped Dan Rather before reading portions of NOAA's press release to CBS viewers, skirting the fact that levels of ozone-

depleting CFC-12, methyl bromide and halons in the atmosphere are still rising.

Yet the director of NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, New

Jersey, Dr. Jerry Mahlman, says, "I don't know why the press ran off the edge on this." He believes that his NOAA colleagues might have overinterpreted their own data. What the Boulder, Colorado, office of NOAA found in its study, he says, "does not mean that ozone depletion will go away soon." Like so many environmental problems before it, this one has slipped off the front page (with the exception of the recent misleading reports), to be replaced by destructive weather, fish shortages and other global emergencies; and enviros have moved on to ancient forests, climate chaos and endocrine disrupters.

But is the ozone crisis really passing, and passé? Recent images from monitoring satellites and ground-based UVB measurements suggest otherwise, and a few scientists who a year ago believed we would be spared an ozone-layer catastrophe are now not so certain. In addition to dead penguins, there are other worrisome signs:

§ The 1995 hole in the ozone layer over the Antarctic was larger than projected by atmospheric models—twice the size of the year before—and it stayed open three and a half months, longer than ever before and considerably longer than expected by many atmospheric scientists. Also last year, the World Meteorological Organization (W.M.O.) reported an unexpected ozone loss of about 35 percent over Siberia and about 15 percent over parts of Canada.

§ This spring, levels of ozone in the stratosphere over the Northern Hemisphere were the lowest on record. At times, the ozone layer was depleted by a record 45 percent over an area stretching from Greenland to Scandinavia and western Siberia. (Prior to 1990, springtime ozone depletion over the Northern Hemisphere rarely reached 3 percent.)

§ This March an unexpected rise in solar radiation—to twice its normal level—was recorded in Glasgow, Scotland, and Cornwall in England. Similar increases likely occurred elsewhere on the planet at the same mid-latitudes, but were undetected for lack of sensing equipment.

"Five years ago I would not have predicted this, particularly in

those latitudes," says NOAA's Mahlman. "It's larger than we can explain easily. Of course, ten years ago we were astounded by Southern Hemispheric losses." Then, Mahlman and other atmospheric scientists were stating with confidence that the South Pole was probably the only place on the planet where such a phenomenon would occur.

"This is certainly significant," observed Dr. Joe Farman upon reviewing the 1996 data. Farman was the British Antarctic Survey scientist who first discovered the southern ozone hole. "We have to get it through to politicians that we have not yet cleaned up this stuff," he adds. "The time has not come for complacency."

But most NASA scientists and other U.S. government officials seem unalarmed, at least in their public statements. They still insist that the ozone layer will be restored to healthy conditions in about fifty years—although some now add a cautionary "five or ten" more to their projections. Government information providers are careful not to call Northern Hemispheric depletion a "hole." Instead, they use "bite" and "cavity" to describe the massive thinning, which on satellite imagery really doesn't look much different from the Antarctic hole. And federal agencies watching over the ozone layer—NASA, NOAA, the Environmental Protection Agency, the Departments of State and Agriculture, and the White House Council on Environmental Quality—assure reporters that the problem remains essentially solved. "I'm not declaring victory," says C.E.Q. climate specialist Steve Seidel, "but assumptions are all overwhelmingly on the right track."

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True, the scientific community admitted that ozone depletion would get worse before subsiding. But "worse" keeps getting worse than most atmospheric scientists or the W.M.O. expected; their models have failed. "We drastically understated the case," says Mahlman, "by a factor of three or four." Now that the evidence has made all projections subject to challenge, a disconcerting question emerges: Are we moving too slowly?

The success of the global ozone-protection strategy rests on six critical assumptions:

§ that all signatories to the Montreal Protocol will faithfully adhere to its provisions;

§ that the industrial North will provide adequate financial support to the efforts of developing countries to phase out ozone-threatening technologies;

§ that 1994 projections of ozone loss and its effects remain accurate and valid;

§ that the recovery and recycling of exhausted ozone-depleting chemicals will be carried out responsibly;

§ that the production and use of methyl bromide—an ozone depletor—will be phased out by 2001 in the United States and by 2010 in much of the rest of the developed world.

§ that during the critical years of ozone recovery, there will be no unanticipated "atmospheric shocks," such as a rapid buildup of greenhouse gases or large volcanic eruptions.

Here's the bad news: the first five assumptions are far from being on track, and it is statistically likely that sometime in the next fifty years an atmospheric shock will occur.

The Montreal Protocol is working in some respects. The growth rate of most ozone-depleting chemicals reaching the atmosphere has been slowed, and as NOAA correctly reported, some are actually in decline. The E.P.A. estimates that the resulting protection from UVB will eventually save more than 6 million U.S. lives from skin cancer. That's all good news. But it does not change the fact that the projected mid-twenty-first-century solution to this problem rests on computer models based on the expectation that all parties to the protocol will behave themselves. Even Dr. Stephen Montzka, author of the NOAA report that generated all those upbeat stories about the prospects of the ozone layer, cautions, "Without widespread adherence to restrictions outlined in the revised Montreal Protocol, additional emissions of chlorinated and brominated compounds could slow or reverse the trends we have observed."

The kind of adherence Montzka desires is simply not happening. Among the protocol's signatories are scofflaws pumping many tons of unanticipated ozone-depleting substances into the atmosphere. Russia, a major producer of CFCs, is the worst but not the only offender. Poland, Bulgaria, Belarus and Ukraine also admit to violating the protocol and together with Russia have petitioned their fellow signatories for a five-year postponement of their phaseout deadlines. This—and unconfessed cheating as well—was not factored into atmospheric models. Nor was bootlegging of the restricted substances.

The protocol and its amendments do create hardships for millions of small businesses worldwide that rely on cooling technologies. In the United States an estimated 600,000 people service air conditioners, refrigerators and other CFC-using devices. The E.P.A. has conducted training programs to encourage responsible replacement and recycling practices among CFC handlers. But not all these service people care about the ozone layer or believe there is a problem. Some listen to Rush Limbaugh's ozone tirades and think depletion is a myth perpetrated by "environmental wackos" and greedy scientists seeking research grants.

In a recent survey of subscribers to *Air Conditioning, Heating and Refrigeration News*, 48 percent of respondents said they did not believe that the chemicals they worked with were damaging the ozone layer. Others simply don't want to pay extra for substitutes, which can run five times the cost of CFCs. Consequently, a black market for illicit CFCs has grown in both the United States and Europe. Estimates of the contraband CFC trade range from 10,000 to 22,000 tons a year, most of it flowing from India, China and the former Soviet republics. The U.S. Customs Service reports that CFC-12, concealed in ordinary pressure cylinders and smuggled mostly through Miami, is a contraband problem second only to illicit drugs. However, the Justice Department has caught and convicted only thirteen black marketers.

Eileen Claussen, Assistant Secretary of State for Oceans and International Scientific Affairs, believes the bootlegging situation is even worse in Western Europe. "Many more tons are

smuggled in, mostly from Russia," she says, citing unspecified intelligence sources. "And to date there has only been one criminal indictment, in the Netherlands." Jerry Mahlman says that smuggled CFCs are not factored into his or other government projections, yet insists that cheating "is our biggest problem. Even 10 percent additional chlorine creates the potential for very large ozone destruction in the Northern Hemisphere." While the estimate of contraband used in the United States remains just under 10 percent of the country's total CFC usage, the worldwide rate is likely higher.

Producers and users of CFCs are not the only cheaters. Vital to the success of the Montreal Protocol is a multilateral fund formed to help developing countries convert to ozone-friendly technologies. Managed jointly by the World Bank and the U.N., the \$510 million annual kitty finances technology transfers to countries like China and India, which have agreed to convert to ozone-friendly refrigeration. Like the protocol itself, the fund is a smart concept—have the North, which exported ozone-depleting technologies to the South, pay for the transition to alternative technologies. But contributors to the fund are shirking their commitments, and the fund itself is structurally flawed. Elizabeth Dowdeswell, executive director of UNEP, calls the situation "critical" and predicts that "failure to meet financial commitments will mean a slowdown of O.D.S. [ozone-depleting substance] phaseouts." Very little money has arrived where it is needed most. But just as disturbing is the fact that many of the loans granted have gone to multinational manufacturers of CFC substitutes that are not much of an improvement. These companies produce HCFCs—CFCs with an extra hydrogen molecule. Airborne HCFCs have a much shorter lifetime than CFCs, but while they are in the stratosphere they do just as much damage to ozone.

World Bank and U.S. officials claim the fund is improving. But major contributors, particularly France, Germany, Italy, Canada, Japan, Russia and the United States, are about 35 percent in arrears. The Clinton Administration is having difficulty persuading the 104th Congress that a \$50 million contribution is a good investment in public health. "If the largest contributor to the fund refuses to contribute," warns Environmental Defense Fund policy analyst Karan Kapoor, "countries like China and India may break their commitments to reduce CFCs."

Mahlman says he hasn't yet factored broken commitments into NOAA models. But he fears that if such cheating unleashes additional ozone-depletors, whole sections of the stratosphere, separate from the Antarctic, could be pushed into a dangerous state of "nonlinearity." This is a condition in which every new molecule of an ozone-harming substance destroys ozone to a greater extent than the previous molecule. "The atmosphere tends to work on a straw-that-broke-the-camel's-back model," explains Arjun Makhijani, a member of the E.P.A.'s Committee on Environmental Policy and Technology. "It tolerates pollutants up to certain critical levels or thresholds, then suddenly gives way. Crossing critical thresholds has already given us nasty surprises." In addition to cheating, smuggling, lackadaisical funding of alternatives, faulty computer projections and ineffective recycling measures—all man-made problems—there is a major unanticipated impediment in nature: the interaction between ozone depletion and greenhouse gases, two environmental problems that

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have been treated as separate phenomena. Mahlman explains: Greenhouse gases trap warm air in the atmospheric layer below the stratosphere, and this causes the stratosphere itself to cool. Polar ice clouds then form in the stratosphere, where ice crystals catalyze ozone depletion. A feedback loop ensues, as the ozone depletion caused by global warming allows more ultraviolet radiation to reach the earth. These rays create more greenhouse gases and additional global warming. That leads to more ozone depletion. The cycle continues, and the loop expands.

Do standard ozone-depletion projections account for this loop? No, says Mahlman. "I'm not sure I'd know how to model it." But he promises to try. Arjun Makhijani says it can't be done. "You simply can't model nonlinearity. It's like chaos."

The other joker in the deck is methyl bromide. A 1994 paper prepared jointly by NOAA, NASA, UNEP and the W.M.O. concluded that eliminating all emissions of methyl bromide, a widely used and highly toxic soil sterilant and commodity fumigant, would make the largest single contribution to the protection of the ozone layer. Makhijani and other atmospheric scientists believe that without severe limitation of its use, methyl bromide could trigger a giant rush of ozone depletion throughout the stratosphere. The 1995 Montreal Protocol's Methyl Bromide Technical Options Committee noted that there are alternatives for about 90 percent of methyl bromide use. Nevertheless, agribusiness spokespeople predict massive crop failures and starvation if methyl bromide is banned. Not all the alternatives are environmentally ideal, but they seem preferable to destroying the ozone layer.

The United States has vowed to phase out methyl bromide by 2001. The European Union, the second-largest user, plans to end its use by 2010. Japan, the third-largest user, has no plans to reduce or phase out methyl bromide. In the United States, a coalition of pesticide manufacturers is trying to undo the scheduled phaseout. (This gang is led by Great Lakes Chemical Company and Ethyl Corporation, the two primary U.S. producers of methyl bromide, and Trical Company, the largest applicator of the chemical.) The group's representative, Peter Sparber, has been lobbying both Congress and the international community. He was an active presence at a meeting of

the Montreal Protocol signatory nations last December in Vienna, where methyl bromide was a major item on the agenda. At that session, the parties failed to impose restrictions on the chemical. Kenya, Spain, Italy, France, Greece, England, Japan and Portugal strongly resisted controls and were able to block a proposed phaseout. The U.S. delegation supported a weak compromise that prevailed and gave the resisters until 2010 to phase out methyl bromide production and allowed numerous exemptions to the controls on its use.

American farmers, particularly Florida tomato and California strawberry growers, are desperate to keep using methyl bromide. Their Congressional representatives are attempting to amend the Clean Air Act to exempt the substance from that law or, at the least, to introduce loopholes for methyl bromide use. (Also in Congress, pesticide industry advocates, such as Republican Representatives John Doolittle and Tom DeLay, introduced bills to postpone the withdrawal of CFCs from the U.S. market, or in DeLay's case, to repeal the ban altogether.) Despite the obvious danger of amending the Clean Air Act with a Republican majority in both houses, the

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Clinton Administration seems receptive to the idea. "Yes, there is some risk involved," admits Steve Seidel, "but we should still open the act and add some use exemptions for vital crops." The E.P.A. defends this position. David Doniger, a senior E.P.A. lawyer, says, "We have to recognize that many parts of the economy have become dependent on ozone-depleting chemicals." In 1992, when Doniger was an employee of the Natural Resources Defense Council, he implored the E.P.A. to order "an immediate sharp cutback in methyl bromide production...and a complete phaseout within five years."

As long as the United States and the other signatory nations remain soft on methyl bromide use, the ozone crisis cannot be considered resolved. The U.N./NASA Scientific Assessments Panel reported that if there is a "significant" increase in the use of methyl bromide and HCFCs, the "recovery of the ozone layer would not occur."

As ozone thins in the Northern Hemisphere, and UVB levels and recommended PABA ratings are included in our weather reports, it seems certain that ozone depletion will return to the front page again before the problem is solved. And next time the news may not be so good. The United States probably won't resort, as Australia has, to fining parents who send their children out to play without sun hats; but our scientists will have to heed new findings and continue to grapple with ozone depletion. The ozone story is a cautionary tale: Global ecological problems are not solved by cordial international treaties, but by tough agreements that lead to aggressive monitoring and extensive follow-up.

Which brings us back to the penguins of Bechervaise Island. Their demise is being quietly researched by a small team of scientists from Australia, and nobody else. This is not surprising. Little money has been spent in researching the biological effects of ozone depletion. Yet we need to know what killed those birds. And whether or not ozone depletion was involved, the threat remains with us. It is, in its own way, a nonlinear breakdown. ■

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