THE IMPROBABLE MONTREAL PROTOCOL: SCIENCE, DIPLOMACY, AND DEFENDING THE OZONE LAYER

Richard Elliot Benedick

Introduction

In January 1985, not long after I took over the international environment portfolio at the State Department, I led a small American delegation to a little-noticed meeting in Geneva. There, the U.S., Canada, and a few like-minded countries tried, and ultimately failed in the face of strong opposition from other governments, to achieve a multilateral agreement to limit use of chlorofluorocarbons (CFCs). The event attracted only perfunctory attention in the press, and its unremarkable results occasioned no diplomatic ripples in national capitals.

For three years, this awkwardly titled *Ad Hoc Working Group of Legal and Technical Experts for the Preparation of a Global Framework Convention for the Protection of the Ozone Layer,* an assemblage of diplomats, environmental officials, and government lawyers under the auspices of a small UN agency, the United Nations Environment Programme (UNEP), had struggled in vain to reach a consensus on controlling CFCs. Two months later, a handful of countries signed the Vienna Convention for Protection of the Ozone Layer, a toothless treaty to encourage ozone research that did not even mention CFCs in its text.

The following year, I was asked by Secretary of State George Shultz and Ambassador John Negroponte, then Assistant Secretary of State for Oceans, Environmental, and Scientific Affairs (OES), to lead negotiations for a protocol on controlling CFCs. Very few gamblers would have wagered at that time that such negotiations could succeed. CFCs were virtually synonymous with modern standards of living, finding new uses in thousands of products and processes. Billions of dollars of international investment and hundreds of thousands of jobs worldwide were involved. Technological alternatives were nonexistent or considered too costly or unfeasible. Powerful governments and global economic interests were aligned in adamant opposition to controls, as were ideological elements within the administration of President Reagan. Still other governments and publics were unaware or indifferent to an arcane threat. Perhaps most significant of all, the arguments for control rested on unproven scientific theories: throughout the protocol negotiations there was firm evidence neither of the predicted ozone layer depletion nor of any harmful effects.

Yet, in September 1987 an international accord was signed in Montreal that made headlines around the globe. By 1989, protection of the ozone layer figured prominently in discussions among the world's political leaders. Within a short time, whole classes of hitherto indispensable chemicals were being phased out and industries were being transformed. CFCs and ozone had become, literally, household words.

The heads of the World Meteorological Organization (WMO) and UNEP later wrote that "the action to defend the ozone layer will rank as one of the great international achievements of the century."[1] Under conditions of great scientific uncertainty and political and economic opposition, the negotiators of the Montreal Protocol averted grave dangers to life on Earth. The protocol also set a number of important precedents that influenced the great wave of environmental diplomacy of subsequent years, including several international treaties as well as the 1992 United Nations Conference on Environment and Development and Agenda 21. What happened between the publication of controversial scientific theories in 1974 and the signing of a landmark treaty in 1987, together with the subsequent evolution of that treaty, is a fascinating and instructive example of how science and diplomacy can effectively interact to address a global threat.

Disturbing Theories

Ozone has been characterized as "the single most important chemically active trace gas in the earth's atmosphere."[2] Two singular characteristics of this remote, unstable, and toxic gas make it so critical. First, certain wavelengths of ultraviolet radiation (UV-B) that damage and cause mutations in animal and plant cells are absorbed by the thin layer of ozone molecules dispersed throughout the atmosphere, particularly in the stratosphere six to thirty miles in altitude; the harmful radiation is thus prevented from reaching the earth's surface. And second, differing quantities of ozone at different altitudes have major implications for global climate. Indeed, the ozone layer, at its natural concentration and diffusion, is essential to life as it has evolved on earth.

In 1973, two University of Michigan scientists, Richard Stolarski and Ralph Cicerone, in the course of examining possible effects of chemical emissions from National Aeronautics and Space Administration (NASA) rockets, theorized that chlorine in the stratosphere could unleash a complex chain reaction that would continually destroy ozone over a period of decades; fortunately, very little free chlorine was thought to exist at that altitude.[3] However, a year later, Mario Molina and Sherwood Rowland at the University of California, Irvine, became intrigued with some peculiar properties of anthropogenic chlorofluorocarbons. Molina and Rowland discovered that, unlike almost all other gases, CFCs were not chemically destroyed or rained out in the lower atmosphere, but rather migrated slowly up to the stratosphere. There they remained for many decades -- some for more than a century. The two researchers concluded that the CFCs, which are not naturally present in the stratosphere, are eventually broken down by radiation and thereby release large quantities of free chlorine.[4]

---

[1] G.O.P.Obasi and Elizabeth Dowdeswell, Foreword to R. Bojkov, *The Changing Ozone Layer*, Geneva: WMO/UNEP, 1995.

[2] Daniel Albritton, *et al., Stratospheric Ozone: The State of the science and NOAA's Current and Future Research,* Washington: NOAA, 1987, p.1.

[3] R.S. Stolarski and R.J. Cicerone, "Stratospheric Chlorine: A Possible Sink for Ozone," *Canadian Journal of Chemistry* 52 (1974).

[4] M.J. Molina and F.S. Rowland, "Stratospheric Sink for Chlorofluoromethanes: Chlorine Atomic Catalyzed Destruction of Ozone, *Nature* 249 (1974).

The combined implications of these two hypotheses were nothing less than sensational: *the protective ozone shield would be seriously compromised.* The enhanced levels of ultraviolet radiation that would penetrate the atmosphere and reach earth's surface could have potentially disastrous impacts on human and animal life and the environment. Scientists projected millions of future deaths from skin cancer, millions of cases of eye cataracts and blindness, dangerous suppression of the human immune system, losses in food production and fisheries, damage to plastics and other materials, and intensification of the greenhouse effect.

Astonishingly, the research paths leading to the suspicion that the stratospheric ozone layer was in jeopardy had been serendipitous; no one had set out to condemn chlorofluorocarbons. For decades, CFCs were considered a multifaceted wonder-chemical, finding ever more uses without fear that they were in any way harmful. Since their invention in the 1930s they had been thoroughly tested by customary industrial standards and declared completely safe. Possible effects thirty miles above the earth had simply never been considered.

The family of CFC chemicals, and their related bromine halon compounds, are stable, nonflammable, nontoxic and non-corrosive – qualities that made them uniquely useful in many consumer and industrial applications. Since CFCs vaporize at low temperatures, they are highly efficient coolants for refrigeration and air conditioning, as well as excellent propellants in spray containers for pharmaceuticals, household products, cosmetics, and cleaners. They make energy-efficient insulators and found use in the manufacture of a wide range of rigid and flexible plastic-foam materials. Their non-reactive properties make them perfect solvents for cleaning microchips and telecommunications equipment, as well as for a myriad of other industrial applications. As an added bonus, CFCs are inexpensive and relatively simple to produce. The related halons are unsurpassed fire extinguishants in the defense, oil, aircraft, electronics and other industries. Although consumed in much smaller quantities than CFCs, halons posed, molecule-for-molecule, an even greater threat to the ozone layer.

Rowland and Molina, together with Paul Crutzen of the Netherlands, became Nobel Laureates two decades later, but the ozone depletion hypothesis was initially greeted with disbelief and controversy in the scientific and business communities. Nevertheless, the serious theoretical dangers prompted a wave of new scientific research over the following years.

It would be difficult to exaggerate the complexities involved. To understand what was happening to the ozone layer, researchers needed to go far beyond atmospheric chemistry. They had to bridge traditional scientific disciplines and examine the earth as an interrelated system of physical, chemical, and biological processes occurring on land, in oceans, and in the atmosphere – processes that were themselves influenced by economic, political, and social forces. Scientists developed ever more sophisticated computer models to simulate, for decades into the future, the stratospheric interplay between radiative, chemical, and physical phenomena. They utilized balloons, rockets, and satellites to track and measure remote gases measured in volumes as minute as parts per trillion of volume.

Ozone itself amounts to considerably less than one part per million of the atmosphere. Intrinsically unstable ozone molecules are continually created and destroyed by complex natural forces involving solar radiation and even more minute quantities of other gases. To complicate the analytical challenge, ozone concentrations fluctuate naturally on a daily, seasonal, and solar-cyclical basis. Indeed, during the 1960s ozone concentrations had actually increased, notwithstanding expanding use of CFCs. Ozone abundance also varies significantly over different latitudes and altitudes. The scientists thus faced an enormous challenge in attempting to detect the miniscule "signal" of the start of a long-term trend as postulated by the theory.

Transatlantic Differences

The United States and the then twelve-nation European Community (EC) dominated the market for CFCs, together accounting for more than 80 percent of the world's output in 1974. Notwithstanding shared political, economic, and environmental values, the transatlantic partners had markedly different views on the potential threat.

The ozone depletion theory seemed to capture the imagination of an American public that was, perhaps because of the U.S. space program, more sensitized than Europeans to events in the stratosphere. Congress, media, and environmental and scientific organizations in the U.S. were quick to voice concern. In contrast, for many years there was no countervailing voice in Europe to the powerful chemical industry. The otherwise environmentally conscious European public accorded higher priority to such closer-to-home problems as acid rain and oil spills.

On both sides of the Atlantic, the chemical, automobile, and other involved industries adamantly denied any linkage between growing CFC use and the long-term stability of the stratospheric ozone layer. Industrialists mobilized research and public relations efforts to highlight the scientific uncertainties, the necessity of CFCs for modern lifestyles, the infeasibility of substitutes, and the presumed high costs and economic dislocations associated with controls on these chemicals.

Differences slowly emerged, however, between American and European industrialists, probably reflecting the relative depth of U.S. public concern. Millions of independent decisions by worried American consumers reduced the U.S. market for spray cans by two-thirds by 1977, even in the absence of governmental regulation. The threat of a patchwork of varying state regulations made U.S. industry open to uniform and therefore relatively less-disruptive federal controls.

Responding to public reaction, Congress authorized the Administrator of the Environmental Protection Agency (EPA) in the 1977 Clean Air Act to regulate "any substance … which in his judgment *may reasonably be anticipated* to affect the stratosphere, especially ozone in the stratosphere, if such effect *may reasonably be anticipated* to endanger public health or welfare" (emphasis added). This law attempted to balance the scientific uncertainties with the fateful risks of inaction. And it opted for a low threshold to justify intervention: the government was not obligated to prove conclusively that a suspected substance could modify the stratosphere or endanger health and environment. All that was required was a standard of reasonable expectation: CFCs would not be considered innocent until proven guilty.

Following this legislation, the United States banned CFCs as propellants for nonessential aerosol sprays in early 1978, affecting nearly $3 billion worth of sales in a wide range of products. Similar action was taken by Canada, a relatively small producer, and by Sweden, Norway, Denmark, and Finland, all importing countries. In contrast, under heavy pressure from such important companies as Britain's Imperial Chemical Industries (ICI), France's Atochem, and Germany's Hoechst, the European Community waited until 1980 before enacting painless measures, fully supported by industry, which gave an appearance of control while permitting unhampered CFC expansion for two more decades.

The divergent U.S. and EC actions were reflected in subsequent economic developments. The year of the ozone hypothesis, 1974, coincidentally represented an historic peak for CFC production and use -- which had been growing an average 13 percent annually since 1960. The United States was at that time by far the major producer, with nearly half of global output, while all EC countries together accounted for less than 40 percent; Germany was the largest European producer, followed by the United Kingdom, France, and Italy.

After its aerosol ban, the United States never regained its former market pre-eminence. By 1986, global CFC production and consumption, which had fallen in the late 1970s following the aerosol ban in the U.S. and elsewhere, had recovered due to new uses and now exceeded the 1974 peak. The EC now dominated the market with an estimated 43-45 percent, while the United States had dropped to about 30 percent. Meanwhile, other countries had increased their shares, especially Japan (11-12 percent) and the Soviet Union (9-10 percent), with smaller amounts for Canada, China, Australia, Brazil, Mexico, Argentina, Venezuela, and India. The European Community also supplied CFCs to the rest of the world, particularly the growing markets in developing countries. EC exports rose by 43 percent from 1976 to 1985 and averaged almost one-third of its production. In contrast, the United States now consumed virtually all it produced.

The EC Commission long based its ozone position largely on the self-serving data and contentions of a few big companies. European industry's primary objective was to preserve market dominance and to avoid the costs of switching to alternative products for as long as possible. Both industry and government officials felt that panic had driven Americans into the 1978 aerosol ban and that the United States had only itself to blame for any market losses. Epitomizing the close EC industry-government linkages, company executives often served on official delegations to the negotiations. Indeed, during the Montreal Protocol negotiations in 1987 we actually came across an official EC instruction drafted on an Atochem corporate letterhead.

The Vienna Convention

UNEP, under the dynamic leadership of its Egyptian Executive Director Mostafa Tolba, recommended from the very beginning a global approach to ozone protection. UNEP began by sensitizing governments and vigorously promoting research and data collection. The question of international controls, which Tolba (himself a scientist) believed essential, was first raised during an April 1977 intergovernmental conference hosted by the United States. At a German-sponsored meeting the following year, however, governments could not agree even on coordinated voluntary CFC reductions because the United Kingdom and France blocked consensus within the EC, which voted as a unit. Around this time, Canada convened what became known as the “Toronto Group,” an informal collection of generally like-minded countries which at various times included representatives from Australia, Austria, Denmark, Finland, New Zealand, Norway, Sweden, Switzerland, and the United States, that began to exchange information and coordinate ozone protection strategies.

By the early 1980s, the sense of urgency for new regulatory action had diminished considerably. Continually changing interpretations of the stratospheric chemical reactions caused estimates of potential future ozone depletion to bounce up and down erratically. Politicians as well as scientists began to wonder whether the original ozone-depletion hypotheses had been overstated. Furthermore, CFC production had declined due to the aerosol bans and global economic slowdown.

Had not Mostafa Tolba persisted in his mission, the ozone issue might well have died at this stage. Even as it was, the intergovernmental negotiations convened by UNEP in 1982 for a global agreement to protect the ozone layer dragged on for three years. Most governments preferred that a convention comprise only research cooperation and not international regulation. However, in 1983, members of the Toronto Group proposed to include a provision to eliminate CFCs in nonessential aerosols, mirroring the actions taken several years earlier by Canada, the U.S., and others. They argued that a worldwide aerosol ban was clearly feasible, as feasible substitutes were now available for at least this usage. Eliminating CFCs in spray cans would yield immediate important benefits for the ozone layer: it would reduce global emissions by about a third and thus buy time for the still-evolving science to provide clearer guidance to policy makers on the possible need for additional controls.

The European Community rejected this idea and countered with a proposal to cap new production capacity. Correctly, EC representatives pointed out that growing non-aerosol uses could eventually cancel out aerosol reductions. The Toronto Group responded that while the EC proposal was theoretically elegant, it was practically ineffectual: under the EC cap, currently underutilized European capacity would permit millions of additional tons of CFCs to be released over the next twenty years. Moreover, such a cap would lock in existing market shares and was therefore biased against countries with little or no surplus capacity, such as the United States.

Whatever the intrinsic merits of the respective proposals, each of the two contending blocs favored an agreement that would require no new controls for itself and considerable adjustment for the other. Faced with this stalemate over regulatory strategies, the negotiators decided to return to the original idea of a research convention, which would at least provide a framework for any future agreement to control ozone-depleting substances.

The Vienna Convention on Protection of the Ozone Layer, signed in March 1985, actually represented the first formal international effort to deal with an environmental danger before it erupted. The signatories accepted a general obligation to take "appropriate measures" to protect the ozone layer. The convention also established mechanisms for international cooperation in research, monitoring, and exchange of data on the state of the stratospheric ozone layer, and on emissions and concentrations of relevant chemicals. These provisions were significant because, before Vienna, several countries had refused even to provide CFC production data.

Over initial European objections, the Toronto Group pushed through a last-minute resolution in Vienna directing UNEP to reopen diplomatic negotiations with a 1987 target date for agreement on a binding CFC control protocol. This resolution simultaneously promoted an innovative scientific fact-gathering and consensus-building process, in the form of informal workshops under UNEP sponsorship, which proved critical to the future formal negotiations.

Models of Uncertainty

In the years following the 1974 scientific hypotheses, model predictions of the impacts of CFC emissions fluctuated widely. Projections of global average ozone depletion for fifty to one hundred years in the future, made by the U.S. National Academy of Sciences and others, started at about 15 percent in 1974, fell to around 8 percent in 1976, climbed again to nearly 19 percent in 1979, and then dropped steadily to approximately 3 percent by 1983. These swings in the estimated danger tended to dampen public and official concern.

Then, in late 1984, a remarkable cooperative international scientific venture was launched to analyze and reassess all available evidence on the present and prospective state of the ozone layer. Under the co-sponsorship of UNEP, WMO, EPA, NASA, the National Oceanic and Atmospheric Administration (NOAA), West Germany's Ministry for Research and Technology, and the European Commission, approximately 150 scientists of various nationalities worked under NASA's leadership for more than a year. The resulting study, *Atmospheric Ozone 1985,* was the most ambitious analysis of the stratosphere ever undertaken: three volumes containing nearly 1,100 pages of text and eighty-six pages of references.

This comprehensive assessment supported, but could not prove, the earlier ozone destruction hypotheses. It revealed that accumulations of CFCs in the atmosphere had nearly doubled between 1975 and 1985. Because these stable chemicals have such long atmospheric lifetimes, millions of tons of prior-year CFC production were still en route to their possibly fatal stratospheric rendezvous with ozone. Even if CFC emissions were to level off or decline, chlorine would continue to accumulate in the stratosphere for many decades, and some future depletion of the ozone layer seemed inescapable. The scientific consensus was that continued CFC emissions at the existing rate could reduce global average ozone by about nine percent in the last half of the twenty-first century, with greater seasonal and latitudinal decreases.

Despite this progress in theoretical understanding, the scientific uncertainties were still formidable as diplomats began in 1986 to debate the need for international controls. Thirty years of recorded measurements had not demonstrated any statistically meaningful ozone depletion over mid-latitudes, as predicted in the models. Nor did the models indicate any global depletion, at existing levels of emissions, for at least the next two decades. Not only was there no evidence of increased levels of UV-B radiation reaching earth's surface, but such measurements as existed actually showed *reduced* radiation. The WMO/UNEP report also noted significant knowledge gaps, inadequacies in the models, and data inconsistencies. Writing in *American Scientist* in 1989, fifteen years after his original controversial treatise, Sherwood Rowland noted that "statistical evaluation through 1986 gave no indication of any trend in global ozone significantly different from no change at all."[5]

The Antarctic Ozone Hole

Too late in 1985 for systematic scrutiny under the WMO/UNEP assessment project, British scientists published previously unpredicted findings based on balloon measurements of ozone made at Halley Bay in the Antarctic. It appeared that stratospheric ozone concentrations recorded during the Antarctic early spring (September-October) were about 40 percent lower than during the 1960s. While the ozone layer recovered toward the end of each spring, the extent of the seasonal ozone collapse, or "ozone hole" (that is, a portion of the stratosphere in which greatly diminished ozone levels were measured), had apparently accelerated beginning in 1979. Total chlorine concentrations over Antarctica, at a natural level of 0.6 parts per billion, had been slowly increasing for decades. However, no effect on the ozone layer was evident until the concentration exceeded two parts per billion, which apparently triggered the totally unexpected springtime collapse. The British group actually initially hesitated to publish their findings because they were considered so fantastic.[6] Ironically, it was later discovered that U.S. and Japanese scientific satellites had not signaled the transitory effect earlier because, in order not to deluge scientists with unmanageable masses of data, the satellite computers were programmed to automatically reject as anomalies any measurements so far below the error range of existing predictive models.

Did the ozone hole influence the subsequent negotiations and make agreement on international controls inevitable? While plausible in hindsight, this popular notion overlooks how little was known about the ozone hole before and during the actual negotiations. There were neither evidence nor explanations as to how CFCs could cause a localized effect, and there were numerous plausible theories other than chlorine to explain the puzzling Antarctic phenomenon. Rowland observed in 1986, just before the negotiations began, that "the causes of the massive seasonal loss of ozone over Antarctica are not yet fully understood, and its implications for the ozone layer above the rest of the earth are also uncertain."[7] Even after the Montreal Protocol was signed a year later, EPA concluded that "the Antarctic ozone hole cannot yet serve as a guide for policy

---

[5] F.S. Rowland, "Chlorofluorocarbons and the Depletion of Stratospheric Ozone," *American Scientist* 77 (1989), p.43.

[6] J. Farman, B.G. Gardiner, and J.D. Shanklin. "Large Losses of Total Ozone in Antarctica Reveal Seasonal Clx/NOx Interaction," *Nature, no. 315 (1985).*

[7] F.S. Rowland, "A Threat to Earth's Protective Shield," *EPA Journal* 12:10 (December 1986).

decisions."[8] We were warned by scientists from NASA, NOAA and elsewhere not to link our negotiating position to the ozone hole, lest conflicting evidence emerge that would undermine our general case for strong controls. The scientific consensus actually placed more confidence in the theoretical models that predicted slow ozone depletion over mid-latitudes, rather than an unexplained seasonal phenomenon over the South Pole. Thus, Antarctica was never mentioned during the negotiations.

In the summer of 1987, a delegation of environmental organizations called on me at the State Department to urge that the final protocol negotiating session, long planned for September, be delayed for six months. They argued that this year's planned Antarctic expedition might show that CFCs were responsible, and therefore enable us to obtain stronger controls. My scientific advisers countered, however, that in the previous year the ozone hole had, contrary to expectations, for some unknown reason actually diminished in size. If the September session were to be postponed and the 1987 expedition showed continuing improvement – a possibility that could not be excluded -- it would provide heavy ammunition for opponents of the protocol. We all finally agreed it was more prudent to take what we could get in September, while designing an unconventionally flexible treaty that could be re-opened on the basis of future science.

Prelude to Negotiations

Despite remaining uncertainties, the scientific activities of 1984-86 had contributed to a growing consensus that at least some international regulation of CFCs was desirable. The evolving science, together with mounting domestic pressures for new controls, also influenced U.S. industry. American companies had long resented the competitive advantage that their European rivals had achieved by escaping regulation in the late 1970s. Not surprisingly, American industry did not want any further U.S. regulatory action that was not also binding on the other major producer countries. Hence in September 1986, the Alliance for Responsible CFC Policy, a coalition of about 500 producer and user companies, announced its support for international controls on CFCs.

This unexpected development broke industry's united front practically on the eve of the protocol negotiations and caused consternation in Europe. Some European industrialists had suspected all along that the United States was using the ozone scare to cloak commercial motivations. They now claimed that American companies had endorsed CFC controls in order to enter the profitable European export markets with substitute products that had been secretly developed. But this suspicion was unfounded: to the dismay of environmentalists, DuPont admitted that it had stopped research on CFC alternatives during 1981, when President Reagan's first EPA Administrator, Anne Gorsuch (who was later forced to resign) declared the ozone layer "a non-problem" and cut her agency's work in this area.

In comparison with subsequent environmental negotiations, the Montreal Protocol was achieved in the astonishingly short period of nine months. Only three one-week negotiating sessions, in Geneva, Vienna, and Geneva again, held from December 1986

---

[8] U.S. EPA, "Protection of Stratospheric Ozone," *Federal Register* 52:239 (December 14, 1987, p.4749.

through April 1987, plus a secret meeting of key delegation heads convened in Brussels by Mostafa Tolba in June, preceded the climactic Montreal conference in September. Notwithstanding their relative brevity, the negotiations were contentious and often heated. The United States and the European Community remained the principal protagonists, differing over nearly every issue at every step of the way.

Still dominated by the governments and chemical industries of the United Kingdom, France, and Italy, the EC maintained that there was time to delay stringent and costly production cuts and wait for more evidence, since the scientific models projected no significant ozone depletion for at least two decades. Initially, the USSR and Japan shared this perspective.

From the outset, the United States and Canada, together with Australia, Finland, New Zealand, Norway, Sweden, and Switzerland, pushed hard for major early reductions in production of ozone-depleting substances. We argued that, because of the decades or even century-long atmospheric lifetimes of CFCs, action had to be taken well before critical concentrations of chlorine accumulated in the stratosphere. Further delay of meaningful action, we maintained, would increase the health and environmental risks unacceptably, thereby necessitating even more costly future measures. In plenary statements, I stressed that "the margin between complacency and catastrophe is too small for comfort," and that "if we are to err, then let us err on the side of caution."[9]

Diplomatic Strategies

Following comprehensive interagency discussions, we formulated a strong U.S. opening position for the Montreal Protocol negotiation: inclusion of the full range, rather than just a few, of known ozone-depleting substances, and a progressive phase-down of these chemicals "by as much as 95 percent" within 12 years. We also had to develop positions dealing with such critical issues as the reference year, commitments by developing countries, trade restrictions, entry into force, future revisions and amendments, and voting procedures for revising the treaty.

We knew that the odds were against us and anticipated fierce opposition to a strong protocol from the European Community, Soviet Union, and Japan, which together accounted for two-thirds of the world's CFC production. Therefore, aided by colleagues in EPA and State Department, I crafted in late 1986 a multifaceted diplomatic strategy to try to persuade as many other governments as possible of the need for strong controls. This strategy was fundamentally based on the science, and I took extreme care that U.S. representatives, in their contacts with the public, media, and foreign governments, make a reasonable case for prudent action without exaggeration.

The European Community posed a particular challenge. Notwithstanding the dominance of France and the UK throughout the Vienna Convention process, we

---

[9] R.E. Benedick, *Ozone Diplomacy – New Directions in Safeguarding the Planet*, Cambridge, MA./London, Harvard University Press, revised edition, 1998, chapters 4 and 6 describe the negotiations in detail.

recognized that the influential EC "troika" role (consisting of previous, current, and past EC presidents in a semiannual rotation) would be filled by Belgium, Denmark, and Germany by the time of the crucial September 1987 conference. In addition, the Netherlands was somewhat inclined toward meaningful actions. We therefore focused special attention on these countries, and I and others visited them periodically during the negotiations. We held ministerial and other high-level policy discussions, held press conferences and media appearances to reach public opinion, and promoted exchanges between our scientists. In particular, Germany, which was a major CFC producer but also had strong environmental traditions, was gaining growing influence within EC councils. I was aided in my efforts here by personal contacts gained during 4½ years at our embassy in Bonn, plus fluency in the language.

In an effort to counteract the influence of Imperial Chemical Industries on the U.K. position, I suggested to some U.S. environmental organizations that they visit British counterparts, who had not hitherto been active on this issue, in order to brief them on the significance of ozone layer depletion. Their efforts met with success, and British activists soon caused pointed questions to be raised in Parliament about the government's position. When this resulted in an official protest from Her Majesty's Government about my role, the relevant State Department office coolly responded that "Ambassador Benedick could not be held responsible for activities of American private citizens abroad." Interestingly, when British scientists were able in 1988 to bring the ozone issue personally before Prime Minister Margaret Thatcher, who had an academic degree in chemistry, the U.K. position changed almost overnight and the British thereafter became a leading proponent of phaseout for all ozone-depleting substances.

We made a point of dispatching high-level scientific missions to try to overcome skepticism in Japan and the Soviet Union, which initially had been even more opposed to CFC controls than the British and French. We exchanged data and findings, and even introduced their scientists to sophisticated aspects of U.S. satellite programs relevant to measuring trace gases in the stratosphere. As this was still in the time of Cold War, I characterized this unorthodox endeavor as "ozone glasnost." This strategy gradually succeeded, and by September, European diehards were nonplussed at Montreal to discover that Japan and the Soviet Union were now more inclined to our camp.

We also reached out to other countries, especially in the developing world, which had been largely indifferent to the ozone issue. We provided about sixty U.S. embassies with materials designed to help them engage their host governments in a continuous dialogue on ozone protection. Through a steady stream of cables between Washington and the embassies, the State Department kept abreast of subtle changes in foreign attitudes and provided new information in response to other governments' concerns. We also prevailed on President Reagan to make ozone a priority issue at the June 1987 Group of Seven Economic Summit in Venice, which further elevated the importance of the outcome of protocol negotiations.

These diverse efforts paid off, as several important actors that had been formally uncommitted at the start of negotiations – notably Argentina, Austria, Brazil, Egypt, Kenya, Mexico and Venezuela – gradually accepted our arguments, while Germany, Denmark, Belgium, and the Netherlands worked behind the scenes to moderate the EC's hard-line opposition.

Domestic Backlash and a Presidential Decision

By the spring of 1987, it had become clear that we could not attain a global agreement at Montreal if we continued to insist on our (deliberately extreme) opening position of a near-total phaseout of CFCs. While not surprising, this posed a dilemma for me as chief negotiator. With intense public scrutiny focused on every move, I had to perform a delicate balancing act in continuing to pursue this goal while not definitively closing the door to eventual compromise on less draconian terms. This was especially essential to maintaining cordial relations and crucial support from constructive forces within American industry.

As a result, however, I came increasingly under crossfire in the U.S. Congress. While some strong pro-environment Congressmen, such as the senior Democratic Representative Henry Waxman of California, complained that I was not pressing hard enough for strong controls, others criticized that we had gone too far. Representative John Dingell, Democrat from Michigan and a powerful committee chairman, charged on the floor of Congress that "our chief negotiator, Ambassador Benedick, and his EPA staff support … are negotiating on a seat-of-the-pants basis." After I called on him and provided a comprehensive private briefing on the issues, Dingell later became a valued ally.[10]

Just as we were making progress on the international front, however, a backlash flared up from anti-regulatory ideologues within the Reagan administration, who seemed to have realized belatedly that the negotiations for a strong treaty might actually be on their way to success. Spearheaded by Interior Secretary Don Hodel, they charged that I had not obtained appropriate policy-level clearances before undertaking the negotiation (which was, of course, false), and that in any case the supporting science was too weak to justify strong controls. Our position had attracted increasing international support as it evolved to advocating a multi-step initial 50 percent reduction – an outcome that we had actually privately hoped from the beginning would be achievable. But even that realistic goal was too much for the ideologues.

In March, a special interagency group was established to dispute and overturn the U.S. position. There was a simultaneous campaign, also waged in some newspapers, to depose me as chief negotiator, accusing me of promoting a "radical negotiating program for international controls … largely out of sight of the Administration." American industry, more pragmatic than ideological, stayed aloof from the campaign to undermine a meaningful protocol.[11]

Following weeks of kangaroo-court type proceedings, the political opponents called for a White House meeting to settle the issue. As Secretary of State Shultz would be on

[10] Benedick, *Ozone Diplomacy*, pp.57-58.
[11] *Ibid.* pp.58-62.

travel, he asked me to represent the State Department. When I appeared at the White House, Secretary Hodel and others of the opposition camp refused to begin discussions, arguing that this was a sensitive political issue and that therefore only presidential appointees, not a career Foreign Service Officer, should be permitted to participate. The senior White House official chairing the meeting, who was somewhat sympathetic to our position, tried to no avail to overcome the objection. As every eye turned on me in the ensuing silence, I suddenly recalled a certificate hanging on my office wall. I stated, "Every Foreign Service Officer has a personal commission from the President. I was appointed by President Eisenhower and have served continuously under seven presidents." The White House chair, who was a lawyer, smiled broadly and declared the meeting open.

While much of the press lampooned Hodel and others for characterizing skin cancer as a "self-inflicted" disease and recommending "hats and sunglasses" as the solution for ozone layer depletion, the domestic cabinet disarray had its effect across the Atlantic, encouraging those governments still opposed to strong controls. Secretary of State Shultz now directed me to prepare an options paper, also to include contrasting arguments drafted by the opposing departments, in order to bring the issue before President Reagan for his personal decision. After all of the learning, planning, traveling, negotiating, testifying, and justifying over the last 2½ years, I and my associates were apprehensive about what the outcome might be.

In June 1987, with the final negotiating session at Montreal less than three months away, I was at the Reichstag in Berlin to deliver an address on the fortieth anniversary of the Marshall Plan when a breathless U.S. Embassy attaché brought me an "Eyes Only" personal cable from the White House. President Reagan thus became the world's first head of state to personally approve a national negotiating policy on ozone protection. Ignoring the advice of some of his closest political friends, the President completely endorsed, point-by-point, the strong position of the State Department and EPA. Is it possibly a coincidence that President Reagan, who later characterized the Montreal Protocol as "a monumental achievement," had been operated on in recent months to remove skin cancers from his face? Only his dermatologist may know for certain…

I was instructed by the President to maintain the U.S. position unchanged at Mostafa Tolba's critical unpublicized meeting of delegation heads in Brussels in the following days, but not to reveal that this was now a presidential decision. Unfortunately, this constraint reinforced our EC opponents in their wishful thinking that the ideologues would carry the day in Washington and that I would soon not be representing the United States in Montreal. They were wrong.

Breakthrough at Montreal

The provisions of the agreement that was finally reached in Montreal on controlling CFCs and halons represented creative solutions to difficult scientific, economic, and equity problems. The heart of the protocol negotiations, and the most hotly contested issues, were the interrelated questions of (a) which chemicals should be regulated, and (b) to what extent and how soon should they be reduced.

Concerning chemical coverage, the EC and others vigorously opposed the position of the U.S., Canada, and their allies, to control all major ozone-destroying substances, rather than just CFCs 11 and 12, which had been the original focus of attention. In the face of deadlock, I gathered support for convening a special scientific conference to evaluate the implications of partial or complete coverage. The meeting, held in Würzburg, Germany in April 1987, subsequently influenced many governments to support our position. The scientists concluded that unless rapidly growing CFC 113 and the highly potent halons were also included, their emissions would lead to major depletion of stratospheric ozone.

The scientists also agreed at Würzburg to assign a weight to each individual chemical according to its ozone-depleting potency. Using this weighting system, the negotiators formulated a provision that allowed the chemicals to be controlled as a combined "basket" rather than individually. This ingenious formulation provided countries an incentive to impose greater reductions on those substances that were relatively more harmful to the ozone layer and/or whose uses were less essential to them. The flexibility offered by this provision was instrumental in gaining the support of many governments for strong controls, mostly notably Japan, which had long opposed limits on CFC 113 because of its importance for their electronics industry.

The most visible and contentious aspect of the protocol negotiations was the stringency and timing of cutbacks. Most participating governments were deeply influenced by the scientific finding, developed midway through the negotiations, that significant damage to the ozone layer would occur under the weaker control options being considered. But the EC moved only slowly and reluctantly away from its original position of minimal controls.

Final success on the control schedules at Montreal was attributable to a combination of factors, including: the American diplomatic and information campaign, which prompted Japan and the Soviet Union, among others, to agree on the need for stronger controls; the vigorous efforts of such delegations as Canada, Austria, Denmark, Egypt, Finland, New Zealand, Norway and others; the growing influence of the Federal Republic of Germany within EC councils; and the personal interventions by UNEP's Executive Director Tolba at the negotiating table and behind the scenes with key developing country governments.

Almost at the last minute, an unexpected deal-breaking obstacle emerged in Montreal. We had always insisted that the reference year against which future reductions would be measured should be a prior year – 1986 -- in order that parties not be tempted to build up their production; this was a fundamental point. Throughout previous negotiating sessions, the Soviet delegation had raised no objection to this point, and we assumed that they were much more concerned about the extent and timing of future reductions than about the base year. Now that these other difficult matters appeared to be settled, however, the chief Soviet delegate suddenly announced during an informal working group session that unless the base year were 1990, his government could not accept the protocol and he would not further discuss the issue.

During a coffee break from this baffling stalemate, the Russian overheard me chatting in German in the corridor with the Austrian negotiation chair, Winfried Lang. Clearly more comfortable speaking in German than with the rapid-fire English of the informal session (with no translation service), he explained to us that the problem was a five-year plan, scheduled to end in 1990, that could not be changed without amending the Soviet constitution – a virtually impossible feat. After we ascertained that the plan provided for only a slight expansion in capacity (which, in light of Soviet economic history, would probably not be attained anyway), Ambassador Lang and I later drafted, on a napkin over lunch, a special treaty clause limited to the Soviet situation. The breakthrough to final agreement had been achieved.

The agreed Montreal Protocol text provided for industrialized nations to stabilize CFC consumption and production at 1986 levels within one year after the treaty entered into force, followed by a 20 percent reduction in 1993-94, and a further cut to 50 percent in 1998-99. These fixed anchor dates for the reductions removed any temptation for governments to stall the protocol's entry into force in hopes of delaying the cutbacks. They also provided industry with firm dates upon which to base their planning. Developing countries were allowed a ten-year grace period before they would undertake commitments, and were pledged technological and financial assistance on terms that would be elaborated at subsequent Meetings of the Parties to the protocol.[12]

After these and other issues were resolved at a final midnight session, the Montreal Protocol on Substances that Deplete the Ozone Layer was signed on September 16, 1987, by representatives of twenty-four nations plus the EC Commission. In his closing address to the plenipotentiaries, Mostafa Tolba summed up the process and its probable impact. Witnessing the fruition of twelve years of personal struggle, he stated: "As a scientist, I salute you: for with this agreement, the worlds of science and public affairs have taken a step closer together … a union which must guide the affairs of the world into the next century." He concluded, prophetically, "This Protocol is a point of departure … the beginning of the real work to come."[13]

The treaty signing attracted worldwide media attention, and it was hailed as "the most significant international environmental agreement in history."[14] Perhaps the most extraordinary aspect of the Montreal Protocol was that it imposed substantial short-term economic costs in order to protect human health and the environment against speculative future dangers -- dangers that rested on scientific theories rather than on proven facts. Unlike environmental agreements of the past, this was not a response to harmful developments or events, but rather preventive action on a global scale.

A unique strength of the Montreal Protocol was that the timing and extent of reductions, as well as the list of chemicals to be controlled, could be changed by the

[12] A summary of the original Montreal Protocol provisions is included at Annex A. See Benedick, *Ozone Diplomacy*, Appendix B, for the full text of the Montreal Protocol.
[13] M.K. Tolba, "Facing A Distant Threat," Nairobi, UNEP, *Information* 87/21, October, 5, 1987.
[14] U.S. Senate, Committee on Foreign Relations, *Ozone Protocol*, Executive Report 100-14, Feb. 19, 1988, p.61.

parties without negotiating a formal new treaty. The protocol was deliberately designed to be reopened and revised as needed on the basis of regularly scheduled scientific, environmental, economic, and technological assessments by independent experts reporting back to the Meeting of Parties. These provisions not only reflected the scientific uncertainties, but also served as a means to bridge the differences at the time of the negotiations between those governments demanding strong controls and those who were less convinced, since the measures agreed at Montreal could be either relaxed or strengthened as new evidence accumulated.

As Mostafa Tolba had predicted, however, the work was far from finished in Montreal.

Alarming New Scientific Findings

Even as the negotiators were hammering out the final compromises in Montreal, an unprecedented international scientific expedition was under way in Antarctica. Using specially designed equipment placed in balloons, satellites, a DC-8 flying laboratory, and a converted high-altitude U-2 spy aircraft, the scientists were tracking stratospheric chemical reactions and measuring minute concentrations of gases. Preliminary results announced about two weeks after the protocol's signing indicated high stratospheric chlorine presence and the worst-ever seasonal drop in Antarctic ozone; until these data could be more completely evaluated, however, scientists remained unable definitively to link CFCs to the ozone hole.

Six months later, in March 1988, a joint NASA-NOAA press conference released the Ozone Trends Panel Report, a new comprehensive international scientific assessment of all previous air- and ground-based stratospheric trace gas measurements, including those from the 1987 Antarctic expedition. The conclusions were sensational: no longer a theory, ozone layer depletion had at last been substantiated by hard evidence. The analysis established that between 1969 and 1986, stratospheric ozone over heavily populated regions of the northern hemisphere, including North America, Europe, and the Soviet Union, China, and Japan, had diminished by small but significant amounts. And CFCs and halons were now implicated beyond dispute -- including responsibility for the ozone collapse over Antarctica.

The new scientific findings were profoundly disquieting. The most alarming implication was that the models on which the Montreal Protocol was based had proven incapable of predicting either the chlorine-induced Antarctic phenomenon or the extent of ozone depletion elsewhere. Most probably, therefore, they were *underestimating* future ozone losses.

Following the Ozone Trends Panel Report, a worldwide consensus for phaseout of the ozone-destroying chemicals began to gather momentum. Calls for the elimination of CFCs took on added urgency because of growing public concern, exacerbated by the long, sweltering summer of 1988, about the prospect of climate change. That the CFCs were themselves greenhouse gases was bad enough. But since several other greenhouse gases

-- carbon dioxide, methane, and others -- partially offset the effect of CFCs on stratospheric ozone, any measures to reduce emissions of these gases in order to mitigate global warming would actually aggravate ozone destruction unless CFC concentrations were drastically reduced.

Further studies during 1989 revealed additional grounds for concern. It appeared that emissions of methyl chloroform and carbon tetrachloride, both widely used solvents, could significantly increase stratospheric chlorine concentrations even if CFCs were eliminated. Moreover, it became apparent that the hydrochlorofluorocarbons (HCFCs), now being developed as promising substitutes for CFCs because of their lower ozone-depletion potential, could further damage the ozone layer if their use were to be greatly expanded. Also, while a related chemical family also being studied as CFC alternatives, the hydrofluorocarbons (HFCs), contained no chlorine to harm the ozone layer, they did have a global warming potential. Thus, in the eyes of many analysts, all of these substances could no longer be considered as more than interim solutions.

Scientific studies now indicated that if existing atmospheric concentrations of chlorine and bromine were merely stabilized, the Antarctic ozone loss would be permanent. In order for ozone levels over Antarctica gradually to recover, and to avoid possibly crossing similar unforeseen atmospheric thresholds in the future, it would be necessary to restore atmospheric chlorine concentrations (then at three parts per billion and rising) to levels at least as low as those prevailing in the early 1970s, namely, two parts per billion. And achieving this gradual recuperation -- a process that would in any event take decades -- would require eliminating all CFCs, halons, methyl chloroform, and carbon tetrachloride, as well as strictly limiting future reliance on the HCFCs.

The Protocol in Evolution

It became evident even in the early months after Montreal that the new treaty was moving industry in directions that two years earlier had been considered illusionary. By providing CFC producers with the certainty that their market was destined to decline, the Montreal Protocol unleashed the creative energy and financial resources of the private sector to find alternatives. Following the treaty's signing, the chemical industry began the race for substitutes. Four months after Montreal, several hundred industry representatives participated in a CFC-substitutes trade fair in Washington. Some user industries did not wait for the chemical companies to come up with substitutes; such companies as Nortel, IBM and Motorola re-examined their manufacturing processes and found ways to eliminate CFCs. In cooperation with a small Florida company, AT&T announced a replacement for CFC 113, derived from citrus fruit, for cleaning electronic circuit boards.

Public-private and other innovative partnerships involving varying combinations of UNEP, governments, nongovernmental organizations, multilateral corporations, and small businesses, sprang up to diffuse new technologies and methods to eliminate CFCs around the world, including in developing nations. Greenpeace invested in a failing East German factory to develop and produce CFC-free refrigerators, which the German and Swiss aid agencies then provided to China and India. DuPont constructed a facility in Britain to provide European markets with the CFC-free aerosols that had been standard in the United States for more than a decade. Japanese and American importers of electronics parts from Thailand, including AT&T, Ford, Honda, and Toshiba, teamed up with EPA and Japan's Ministry of Trade and Industry to provide non-CFC technologies to their suppliers. More than 40 multinational companies from eight countries, including Asea Brown Boveri, British Petroleum, Hitachi, and Honeywell, joined to help Viet Nam phase out CFCs.

Significantly, DuPont had announced back in 1986 that it could develop substitutes within about five years, but that "neither the marketplace nor regulatory policy ... has provided the needed incentives" to justify the required investments.[15] Now the incentives were there, and DuPont -- the world's largest producer of CFCs – committed itself, even before any national government did, to cease production of all CFCs and halons by the end of the century.

Thus began a phase for the Montreal Protocol unprecedented in diplomatic history. Responding to the scientific evidence taking a dramatic and unexpected turn for the worse, the parties began to strengthen the treaty's provisions. Existing controls were significantly tightened and dozens of new chemicals were added to the original eight controlled substances. Beginning in 1990 in London, successive Meetings of Parties established and subsequently shortened phaseout schedules for numerous chemicals. The original CFCs and halons would be phased out more rapidly than any of the negotiators at Montreal would have dreamed possible.

A completely new type of financial mechanism, the Multilateral Fund, was created to assist developing countries in acquiring new technologies. The parties also developed a unique institutional structure of specialized subsidiary bodies and committees under the protocol to meet unanticipated issues of compliance, financing, technology transfer, and implementation. Features of these various mechanisms have served as models for several subsequent international environmental accords, including treaties on climate, biological diversity, and desertification, as well as the Global Environment Facility.[16]

Although the work of protecting the ozone layer is still not completely finished, the major challenges have been successfully addressed. The industrialized countries have either phased out, or are in process of phasing out, all of the major ozone-depleting substances as well as the less-damaging transitional chemicals. Developing countries have also accepted phaseout schedules as a great wave of new technologies is being diffused around the world. Over 180 nations have ratified the protocol.

Now, the ozone layer is slowly beginning to recover.

---

[15] "DuPont Position Statement on the Chlorofluorocarbon-Ozone-Greenhouse Issues," *Environmental Conservation*, 13:4 (Winter 1986), p.363.

[16] Details of the protocol's further evolution are found in Benedick, *Ozone Diplomacy,* chapters 14-18.

Lessons for Modern Diplomacy

The problem of protecting the stratospheric ozone layer presented an unusual challenge to both scientists and diplomats. Neither military power nor economic might were relevant factors. It required neither great wealth nor sophisticated technology to produce large quantities of ozone-destroying chemicals. Traditional notions of national sovereignty become questionable when local decisions and activities can affect the well-being of the entire planet. The very nature of ozone depletion meant that no single country or group of countries, however powerful, could effectively solve the problem. Without far-ranging scientific, political, and economic cooperation, the efforts of any individual nation to protect the ozone layer would be vitiated.

The Montreal Protocol was by no means inevitable; knowledgeable observers had long believed it would be impossible to achieve. The ozone negotiators confronted formidable political, economic, and psychological obstacles. The dangers of ozone depletion could touch every nation and all life on earth over periods far beyond politicians' normal time horizons. But although the potential consequences were grave, they could neither be measured nor predicted with certitude when the diplomats began their work. The concept was not obvious: a perfume spray used in Paris could contribute to destroying a remote gas in the stratosphere and thereby bring about skin cancer deaths and species extinctions half a world distant and several generations into the future.

Against this background, industrial interests initially claimed that new regulations would cause severe and unnecessary economic hardship. Technological solutions were either nonexistent or were considered unacceptable by most major nations. Some governments allowed commercial self-interest to influence their interpretations of the science: uncertainty was used as an excuse for delaying decisions. Some political leaders were prepared to accept speculative long-term environmental risks rather than to impose the tangible near-term costs entailed in limiting products seen as important contributors to a modern standard of living. Short-range political and economic concerns were, therefore, formidable obstacles to cooperative international action based upon the theory of ozone-depletion.

Nevertheless, the international community was ultimately successful in its approach to defending the stratospheric ozone layer. This experience suggests several elements of the new diplomacy that is needed to address global ecological threats.

1. *Scientists must assume a critical new role in international negotiations.*

   Without modern science and technology, the world would have remained unaware of an ozone problem until it was too late. Science became the driving force behind ozone policy. Research in support of the ozone protocol was a truly multidisciplinary effort, involving stratospheric chemists, physical chemists, meteorologists, oceanographers, biologists, engineers of all types, soil chemists, agronomists, toxicologists, botanists, oncologists, entomologists, and more. The formation of a commonly accepted body of data and analyses and the narrowing of ranges of uncertainty were prerequisites to a political solution among initially widely separated national interests.

In effect, a community of scientists from many nations, dedicated to scientific objectivity, developed through their research a common concern for protecting the planet's ozone layer that transcended divergent national allegiances. Close collaboration between scientists and key government officials, who also became convinced of the long-term dangers to the ozone layer, ultimately prevailed over more parochial and short-run interests. Governments must sponsor relevant research, while, for their part, scientists must assume responsibility for analyzing the implications of their findings for alternative response strategies.

2. *Political leaders may need to act even while there are still scientific ambiguities, based on a responsible balancing of the risks and costs of delay.*

Unfortunately, current tools of economic analysis are not adequate for this task and can be deceptive indicators; they are in urgent need of reform. The customary methods of measuring national income do not satisfactorily reflect ecological costs -- especially those far in the future. Politicians should nevertheless resist the tendency to assign excessive credibility to self-serving economic interests that demand scientific certainty, and who insist that, because dangers are remote, they are therefore unlikely. By the time the evidence on such issues as ozone layer depletion and climate change is beyond dispute, the damage could be irreversible and it may be too late to avoid serious harm to human life and draconian future costs to society. The signatories at Montreal risked imposing substantial short-run economic dislocations even though the evidence was incomplete; the prudence of their decision was demonstrated when the scientific models turned out to have actually underestimated prospective ozone depletion.

3. *A well-informed public opinion can generate pressure for action by hesitant politicians and private companies.*

The findings of scientists must be interpreted and communicated to a wider public. The interest of the media in the ozone issue and the use of television and press by U.S. diplomats, environmental groups, and legislators through Congressional hearings in the 1970s, greatly influenced public opinion and governmental decisions. Informed and aroused consumers brought about the collapse of the CFC aerosol market in America. It is worth noting that the proponents of ozone layer protection generally avoided invoking apocalypse in their educational efforts; they resisted the temptation to overstate their case in order to capture public attention. Exaggerated pronouncements and selective use of scientific data can damage credibility and make it easier for interest groups that want to prevent or delay action.

4. *Strong leadership by major countries and/or institutions can be a significant force in mobilizing an international consensus.*

UNEP helped to coordinate early research efforts, informed world public opinion, and played a crucial catalytic and mediating role during the negotiating and implementation phases of the protocol. UNEP also provided an objective international forum, free of the time-consuming debates on extraneous political issues that often interfere with the work of UN bodies.

United States political, scientific, and diplomatic leadership also proved critical before, during and after the ozone negotiations. No single country, however, can prevail; alliances must be forged, including those between North and South. On the ozone issue, the U.S. government actively collaborated on policy with Canada and the like-minded Toronto Group of nations. The U.S. also financed substantial domestic and international scientific research. Together with its allies, it developed a strategy for protecting the ozone layer and then promoted international acceptance with ingenuity and tenacity. Because of its population size, geographic expanse, and economic and scientific strength, the United States can have a great positive influence on finding solutions to global issues.

5. *A leading country or group of countries can take preemptive environmental protection measures, even in advance of a global agreement.*

Such actions can slow dangerous trends and thus buy time for future negotiations and for development of technological solutions. Preemptive measures can serve to legitimize change and thereby undercut the arguments of those who argue that change is impossible. The ban on aerosols by the U.S., Canada and others in the late 1970s relieved pressure on the ozone layer and lent greater moral credibility to our campaign, several years later, for even more stringent global controls.

Although unilateral environmental protection measures might, in the short run, adversely affect a country's international competitiveness, it can also, through stimulating research into alternative technologies, give that nation's industry a head start on the future. Moreover, short-term negative impacts can, if necessary, be offset by trade restrictions against products of trading partners that are not subject to comparable environmental controls. During the ozone protocol negotiations, the U.S. Congress threatened such action.

6. *Both nongovernmental organizations (NGOs) and industry are major participants in the new diplomacy.*

NGOs involved in multilateral negotiations now include not only environmental groups, but also organizations representing local governments, women, labor, agriculture, religion, youth, indigenous peoples, academic and research institutions, and more. Since the preparations during the early 1990s for the

United Nations Conference on Environment and Development (the 1992 Rio de Janeiro "Earth Summit"), these groups now comprise an international network, Linked electronically, they regularly consult, coordinate positions, and work jointly to influence government positions and negotiations.

The activities of both industry and citizens' groups in research, publicizing data, and lobbying governments influenced the international debate on the ozone layer. Environmental organizations also play a supportive role in monitoring compliance by government and industry with international commitments. The financial and intellectual resources of the private sector make its involvement and cooperation indispensable, since society ultimately depends on industry to provide the technological solutions.

7. *The effectiveness of a regulatory agreement is enhanced when it employs realistic market incentives to encourage technological innovation.*

Technology is dynamic, and not, as often implied by those who resist change, a static element. If the market is left completely on its own, however, it may not necessarily bring forth the right technologies for environmental protection. Although the 1987 ozone protocol established targets that were initially beyond the reach of existing best-available technologies, the goals were in fact achievable for most of industry -- thereby averting monolithic industrial opposition that might have delayed international action.

The Montreal Protocol was not, as some ideologues charged, a "radical" treaty. On the contrary, it was an expression of faith in the market system. By getting the protocol on the books with a goal of 50 percent reductions, the negotiators effectively signaled the marketplace that research into solutions would now be profitable. Competitive -- and collaborative -- forces then took over, and solutions were developed much sooner, and at lower cost, than had earlier been anticipated. The Montreal Protocol stimulated a virtual technological revolution in the international chemical, telecommunications, pharmaceutical, and numerous other industries.

8. *Economic and structural inequalities between North and South must be adequately reflected in an international regulatory regime.*

In the longer run, the developing countries, with their huge and growing populations, could undermine efforts both to protect the ozone layer and to forestall global climate change. They did not cause these problems, and the rich nations that were responsible must now help them to implement the necessary environmental policies without sacrificing their aspirations for combating poverty and improving standards of living. For many developing countries, the Montreal Protocol process provided the first intensive exposure to environmental problems, leading to the development of internal capacity to deal with other environmental challenges.

Under the leadership of UNEP, the parties to the Montreal Protocol broke new ground in developing and implementing mechanisms for providing reasonable financial assistance and transferring the needed technology, while preserving intellectual property rights and incentives for private entrepreneurship. Such unique features as the first-ever multilateral environment fund, incremental cost funding, balanced voting procedures, public-private partnerships for promoting capacity building and technology transfer, and a sensitive compliance mechanism, all represented an innovative new approach to North-South relations.

9. *The size and format of a negotiation may significantly influence the results.*

It is worth noting that the 1986-87 ozone negotiations, which produced the first and most innovative breakthroughs, were remarkably small in attendance and short in duration by today's standards. The first one-week negotiating round in 1986 was attended by merely 20 nations and three or four NGOs. Just nine months later, at the decisive Montreal conference, there were still only about 60 delegations. Contrast this with the theatrical atmosphere of contemporary two-week global environmental mega-conferences and negotiations on climate and similar issues, which drag on for years. Thousands of official delegates from over 180 nations are outnumbered by even more thousands of nongovernmental observers and media. Scores of ministers and international agency heads add to the extravaganza.

The U.S. delegation at the Kyoto climate protocol negotiations in 2000 consisted of over 150 representatives from 12 different government agencies; other major countries, and even some NGOs, had comparably outsized delegations – exceeding the total number of participants from all countries at the ozone negotiations preceding Montreal! In addition, legions of NGO observers stage noisy and sometimes even violent demonstrations at the conference site, and provide the avid media with sharp critiques of the official proceedings. Indeed, the atmosphere at recent global negotiations seems to place a premium on short-term political sound bites rather than on sober reflection and reasoned debate of very complicated long-term issues. Yet, there is no law that states that every aspect of complex scientific and environmental problems must be addressed by every nation at the same time and in the same forum, in an overheated atmosphere of public scrutiny. Perhaps this is one lesson from the Montreal Protocol history that has not been learned.

10. *Finally, the signing of a treaty is not necessarily the decisive event in a negotiation; the process before and after ratification is critical.*

The Montreal Protocol broke new ground in its planning process. The complicated ozone protection issue was deliberated separated into manageable components, and informal collaborative efforts – scientific workshops, policy conferences, ad hoc consultations – established an environment conducive to building personal relationships and generating creative ideas. Extensive scientific and diplomatic groundwork thus enabled the subsequent formal negotiations to move forward relatively rapidly.

Unlike traditional international treaties that attempt to cement a status quo, the Montreal Protocol was deliberately designed to become a dynamic and flexible instrument. The proponents of strong controls were pragmatic: we did not insist on an ideal solution that might have unnecessarily prolonged the negotiations. Instead, we emphasized getting a reasonable agreement in place that could serve as a springboard for future action. The 1987 protocol did not attempt to predetermine every future step: many important issues were marked, but left open for future resolution, including the financial mechanism, trade restrictions, and compliance procedures. In subsequent negotiations, whenever there were large disagreements, every attempt was made to reach consensus rather than bludgeon the minority. A useful and repeated technique was for the parties to commission studies by outside experts, gradually building up the weight of scientific and technical analysis and illuminating the policy options. When differences remained, instead of postponing action the treaty moved forward with modest short steps, which sent the right signals to industry and set stage for future stronger measures.

By providing for periodic scientific, environmental, economic, and technological assessments by independent expert panels, the negotiators made the treaty adaptable to evolving conditions. Indeed, the essence of the Montreal Protocol is that, far from being a static solution, it constitutes an ongoing process.

* * *

Ultimately, it seems to me that the ozone treaty has defied the efforts of a generation of academics to produce connect-the-numbers guides to successful global negotiation. Although it is useful to analyze, in retrospect, successful negotiating factors and techniques, real negotiations are both richer and more treacherous than academic models. One can offer some “lessons” – as this list of items attempts to do -- but there is no guarantee that things will work out. Impasses are not always destined to be resolved.

The crucial intangible factor is leadership, by governments and by individuals. Individuals can make a surprisingly significant difference in the course of long and difficult negotiations. From the overall leadership on ozone provided by UNEP's Mostafa Tolba, to the roles of individual scientists, negotiators, environmentalists, and industrialists, it was personal ideas, decisions, and actions at a given critical moment that determined the successful outcome. In the final account, diplomacy still remains more of an art than a science. Much depends on serendipity, and on the right people being in the right place at the right time.

In conclusion, in the realm of international relations there will always be resistance to change, and there will always be uncertainties – scientific, political, economic, psychological. Faced with a new generation of global environmental threats, governments must act while some major questions remain unresolved. In achieving the Montreal accord, consensus was forged and decisions were made on a balancing of probabilities -- and the risks of waiting for more complete evidence were finally deemed to be too great. In the real world of ambiguity and imperfect knowledge, the Montreal Protocol may hopefully be the forerunner of an evolving partnership between scientists and policy makers, as sovereign nations seek ways of dealing with uncertain dangers and accepting common responsibility for stewardship of planet Earth.

Annex A

Montreal Protocol on Substances That Deplete the Ozone Layer

Summary of Provisions

(as signed on September 16, 1987)[17]

- Controlled substances include CFCs 11, 12, 113, 114, and 115, and halons 1211, 1301, and 2402. For purposes of calculating control levels, the production, imports, and exports of each chemical are weighted by an individual ozone depletion potential estimated for each chemical.
- Entry into force (EIF) requires at least eleven signatory nations representing at least two-thirds of estimated 1986 global consumption of controlled substances.
- Consumption and production of CFCs will be frozen at 1986 levels beginning six months after the date of EIF. (Consumption is defined as production *plus* imports *minus* exports to parties.)
- Consumption and production of halons will be frozen at 1986 levels beginning three years after EIF.
- Consumption and production of CFCs will be reduced to 80 percent of 1986 levels beginning in the period July 1993 to June 1994.
- Consumption and production of CFCs will be further reduced to 50 percent of 1986 levels beginning in the period July 1998 to June 1999.
- An additional 10 percent of production will be allowed for purposes of supplying developing nations until June 30, 1998. On July 1, 1998, this percentage will increase to 15 percent.
- Low-consuming developing nations are allowed to increase consumption up to 0.3 kilograms per capita for a period of ten years in order to meet "basic domestic needs." After ten years, the developing nations must follow the reduction schedule.

[17] The full text of the original Montreal Protocol and the 1990 London Amendments, together with texts and tables summarizing further significant revisions of the protocol and a list of ratifying parties, are found in Benedick, *Ozone Diplomacy,* pp. 353-394.

- Scientific, environmental, economic, and technological assessments by independent expert panels will be made beginning in 1990 and at least every four years thereafter.
- Import of any controlled substance in bulk from nonparty states is prohibited beginning one year after EIF. Import from nonparty states of products containing CFCs is banned beginning four years after EIF.
- Within five years after EIF, parties will determine the feasibility of banning or restricting trade in products made with CFCs.
- Canceling the 50 percent reduction step would require a vote of two-thirds of parties together representing at least two-thirds of the calculated level of consumption of all parties to the protocol.
- Other adjustments and reductions require a vote of two-thirds of parties together representing at least 50 percent of consumption.
- Addition of new controlled substances to the agreement requires a simple majority of two-thirds of the parties.

SELECT BIBLIOGRAPHY

Andersen, Steven, and K.M. Sarma. 2002. *Protecting the Ozone Layer: The United Nations History*. Sterling, VA and London: Earthscan.

Barrett, Scott. 2003. *Environment and Statecraft – The Strategy of Environmental Treaty-Making.* Oxford and New York: Oxford University Press.

Benedick, Richard E. 2001. "Contrasting Approaches: The Ozone Layer, Climate Change, and Resolving the Kyoto Dilemma." In *Global Biogeochemical Cycles in the Climate System*, ed. E-D Schulze, *et al.,* Max Planck Institute for Biogeochemistry. San Diego, London, Tokyo: Academic Press (Harcourt Brace).

Benedick, Richard E. 2001. "Striking A New Deal on Climate Change." National Academy of Sciences, *Issues in Science and Technology,* Fall 2001. (See also comments in "Forum," Winter 2001.)

Benedick, Richard E. 1998. *Ozone Diplomacy – New Directions in Safeguarding the Planet.* Enlarged edition. Cambridge, MA and London: Harvard University Press.

Brack, Duncan. 1996. *International Trade and the Montreal Protocol.* London: Royal Institute of International Affairs.

Cook, Elizabeth, ed. 1996. *Ozone Protection in the United States.* Washington, DC: World Resources Institute.

Farman, James, B.G. Gardiner, and J.D. Shanklin. 1985. "Large Losses of Total Ozone in Antarctica Reveal Seasonal Cl_x/NO_x Interaction." *Nature, no. 315.*

French, Hilary. 1997. "Learning from the Ozone Experience." In Worldwatch Institute, *State of the World 1997*. New York: W.W. Norton.

Lang, Winfried, ed. 1996. *The Ozone Treaties and Their Influence on the Building of International Environmental Regimes.* Vienna: Oesterreichische aussenpolitische Dokumentation.

Le Prestre, Philippe, *et al*., eds. 1998. *Protecting the Ozone Layer: Lessons, Models, and Prospects*. Boston, Dordrecht, London: Kluwer Academic Publishers.

Molina, Mario, and F.Sherwood Rowland. 1974. "Stratospheric Chlorine: A Possible Sink for Ozone." *Nature*, no.249.

National Oceanic and Atmospheric Administration, NASA, UNEP, and WMO. 1995. *Scientific Assessment of Ozone Depletion: 1994.* Geneva: WMO.

Parson, Edward. 1993. "Protecting the Ozone Layer." In *Institutions for the Earth: Sources of Effective International Environmental Protection*, ed. P.M. Haas, *et al.* Cambridge, MA: MIT Press.

Solarski, Richard, and Ralph Cicerone. 1974. "Stratospheric Chlorine: A Possible Sink for Ozone." *Canadian Journal of Chemistry,* no. 52.