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PETER M. MORRISETTE*

The Evolution of Policy Responses to Stratospheric Ozone Depletion * *

ABSTRACT

Depletion of stratospheric ozone emerged as a political concern in the early 1970s in the United States in the debate over the development of a commercial fleet of supersonic transports. In the mid 1970s it became a major political issue with regard to the use of CFCs in aerosol spray cans, and in 1978 the United States banned the nonessential use of CFCs as aerosol propellants. Efforts at negotiating an international agreement controlling CFC use began in the 1980s and culminated in the 1987 Montreal Protocol. This paper traces the evolution of policy responses to stratospheric ozone depletion. The evolution of stratospheric ozone depletion policy can best be understood as a two-stage process. The first stage involves the emergence of stratospheric ozone depletion as a domestic issue in the United States and several other countries in the 1970s, while the second stage focuses on its transformation to an international issue in the 1980s. In addition to the emergence of stratospheric ozone depletion as an international political issue, three other factors are important in understanding the sources of the Montreal Protocol: (1) the evolving scientific understanding of the problem, (2) increasing public concern over the problem based on the threat of skin cancer and the discovery of the Antarctic ozone hole, and (3) the availability of acceptable substitutes for CFCs.

INTRODUCTION

Representatives from 24 nations, meeting in Montreal in September 1987, signed the "Montreal Protocol on Substances that Deplete the Ozone Layer,"1 an international agreement designed to reduce the worldwide production and use of chlorofluorocarbons (CFCs). This protocol is the result of years of negotiation fostered by the United Nations Environment Programme (UNEP) among the major CFC producing countries. Its formulation was a response to a growing international consensus on the need to protect stratospheric ozone from depletion by CFCs. The Montreal Protocol is a landmark agreement in that it is the first international treaty for mitigating a global atmospheric problem before serious environmental impacts have been conclusively detected. As such, the Montreal Protocol has stirred much interest, and both scientists and policymakers have suggested that it can be used as a model for international agreements on other global environmental problems, especially the problem of C02 and trace-gas induced global warming.

Before such a comparison to other environmental problems can be made, however, it is useful to understand the Montreal Protocol in its historical and political context. Depletion of stratospheric ozone is an example of both the complicated and the global nature of contemporary environmental problems, and the Montreal Protocol shows that innovative approaches to such global environmental problems are possible. During the past two decades concern over stratospheric ozone has evolved from a fringe environmental issue to a major policy issue of national and international importance. An analysis of this evolution is important for understanding both the value of the Montreal Protocol and its implications for other global atmospheric problems.

The evolution of stratospheric ozone policy can be understood as a two-stage process: (I) the development of domestic regulations controlling CFC use in aerosol spray cans in the United States and several other countries in the mid- and late-1970s, and (II) the development of an international policy response to the problem of global stratospheric ozone depletion in the 1980s. These are not separate issues. The development of an international response clearly followed from the concern raised in the United States, Canada, Sweden, and other countries which had taken unilateral action to control CFCs in the 1970s. However, many important differences between stage I and II make this distinction a useful tool for analysis. I argue that four key factors are important in understanding the evolution of stratospheric ozone policy: (1) the recognition that ozone depletion is a global problem requiring an international response; (2) the evolving scientific understanding of stratospheric ozone depletion and its influence on policymakers; (3) increasing public concern based on the threat of skin cancer and the perception of the potential for global catastrophe associated with the discovery of the Antarctic ozone hole; and (4) the availability of acceptable substitutes for CFCs.

This paper analyzes the evolution of stratospheric ozone policy. The first section reviews the science behind the problem of CFC-induced stratospheric ozone depletion. The next two sections discuss the emergence of stratospheric ozone depletion as a national political issue in the United States during stage I, and its evolution to an international political issue during stage II. This is followed by a discussion of how the evolving scientific understanding of the problem, the catastrophic nature of the risks, and the availability of alternatives to CFCs influenced the final negotiations on an international agreement. The last section examines the Montreal Protocol and discusses its prospects for success.

CFCs AND THE OZONE LAYER

Chlorofluorocarbons are a group of inert, nontoxic, and nonflammable synthetic chemical compounds used as aerosol propellants, in refrigeration and air conditioning, in plastic foams for insulation and packaging, and as solvents for cleaning electrical components. There are many varieties of CFCs; CFC-11 and -12 are the most common compounds and CFC-113 has important industrial applications as a solvent. Production of CFCs has increased significantly since the 1960s, reaching a peak in 1974 before declining as a result of the decreasing use of CFCs as aerosol propellants. However, nonaerosol use continued to increase and by the mid-1980s CFC production again reached mid-1970 levels (see Figure 1). Atmospheric concentrations of CFC have also been increasing (see Figure 2). Once in the atmosphere, CFCs have a lifetime of about 100 years. It is this long lifetime that is the root of the problem with CFCs.

Initially, it was believed that these compounds were environmentally safe, but in the early 1970s independent research efforts pointed to a potentially serious problem connecting CFCs with stratospheric ozone depletion.2 Molina and Rowland first suggested that CFCs might play a role in depleting ozone in the stratosphere, the region of the atmosphere at altitudes from about 12 to 50 km.3 Ozone (O_3) in the stratosphere (commonly referred to as the ozone layer) shields the earth from harmful ultraviolet radiation. Molina and Rowland's theory suggested that CFCs diffuse upward into the stratosphere, where they are broken down by ultraviolet radiation, releasing free chlorine which reacts catalytically with ozone and results in its significant depletion. Recent research continues to point to the role of CFCs in depleting stratospheric ozone.4 In addition, other synthetic chemicals have been identified as potential stratospheric ozone depleters: most notable are the halons used in fire extinguishers.5

The stratospheric ozone layer shields the earth from harmful UV-B radiation.6 An increase in the amount of UV-B radiation reaching the surface of the earth could have significant negative effects on human health, plants, and aquatic ecosystems.7 The most significant human health effect is an increase in the incidence of skin cancer. The U.S. Environmental Protection Agency (EPA) estimates that a one percent decrease in ozone could result in a two percent increase in UV-B,8 and a one percent increase in UV-B could result in a two to five percent increase in the rate of non-melanoma skin cancers.9 In addition, increased UV-B may also result in an increase in the rarer but more deadly malignant melanoma skin cancers. The EPA has estimated that if CFC use continues to grow at 2.5 percent a year until 2050, an additional 150 million skin cancer cases could result, causing more than 3 million deaths in the U.S. population born before 2075.10 Other potential health effects include suppression of the immune system leading to a higher incidence of some infectious diseases, and eye disorders such as cataracts or retinal damage.11 Table 1 summarizes the potential human health effects of increased UV-B radiation. Research also suggests that increased UV-B radiation could result in decreased crop production,12 and change in the species composition of natural aquatic ecosystems resulting in more unstable ecosystems.l3

In addition, CFCs are also an effective greenhouse gas in the lower atmosphere.14 Recent assessments conclude that, together, greenhouse gases other than CO2 may be about equal to CO2 in their effectiveness as greenhouse gases.15 Of these other trace gases, CFCs are a significant contributor to the greenhouse effect.16 Table 2 lists the key greenhouse gases and their current rate of increase. Given the present rate of increase of all greenhouse gases, the radiative equivalent of a doubling of C02 (an average global warming of 1.5-4.5 degrees C)17 could be reached by as early as 2030.18 Any action taken to control CFCs in order to protect the ozone layer also acts to contain global warming.

Of recent concern has been the appearance of a hole in the ozone layer over Antarctica during the spring. In 1985, a team of British researchers, using data from the British station at Halley Bay, reported that a massive reduction in the concentration of ozone was occurring over Antarctica during September and October. Data from 1984 indicated as much as a 40 percent loss of ozone as compared to measurements taken 20 years earlier.19 Satellite data supported these findings and indicated substantial reductions since the late 1970s.20 Measurements from 1987 indicate the largest seasonal reduction yet--in excess of 50 percent overall and 95 percent at altitudes between 15 and 20 km.21

The Antarctic ozone hole stirred considerable interest among scientists because it had not been predicted by existing models of atmospheric chemistry. Several theories explaining the appearance of the ozone hole, based on both natural and anthropogenic sources, have been suggested.22 Data from 1987, released after the Montreal Protocol was signed, suggest that CFCs and other anthropogenic pollutants are responsible for the ozone hole. However, the magnitude of the problem is also due to meteorological conditions unique to the Antarctic.23 Despite continued debate about its specific cause, the ozone hole has focused world attention on CFCs and stratospheric ozone depletion.

Ozone depletion has also been detected outside the Antarctic. Satellite data indicate a global reduction in ozone of about five percent since 1978, of which only half can be accounted for by current theories and models.24 However, the accuracy of these satellite measurements has been questioned.25 More recently, the Ozone Trends Panel26 using ground-based measurements for the period 1969-1986, has reported a global reduction of between 1.7 and 3.0 percent in the northern hemisphere for latitudes between 30 and 64 degrees.27 Decreases, however, have been as great as 6.2 percent during the winter months. The Ozone Trends Panel has attributed this decrease to CFCs and other atmospheric trace gases. The Ozone Trends Panel also concludes that these findings are "broadly consistent" with model calculations.28 It is important to note, however, that the results of the Ozone Trends Panel were released six months after the Montreal Protocol was signed, and thus did not influence the outcome in Montreal .

STAGE 1: OZONE DEPLETION AS A NATIONAL ISSUE

During stage I of the process of formulating stratospheric ozone policy in the early and mid-1970s, CFC-induced stratospheric ozone depletion emerged as a major environmental and political issue primarily in the United States. While other nations (Canada and the Scandinavian countries) were concerned about the problem, most European countries (particularly the EEC countries) showed little interest. There were several reasons for this difference. First, the threat of stratospheric ozone depletion from the proposed fleet of U.S. commercial supersonic transports was one of several potential environmental impacts that had been used by environmentalists to stop the project. Thus, the threat of stratospheric ozone depletion was already an environmental and political issue in the United States before the role of CFCs as ozone depleters was discovered. Second, U.S. public interest over the fate of the ozone layer was built both on the growing importance of environmental problems as political issues and on the growing public concern with cancer and the substances and activities that might cause it. Third, the Europeans were not convinced that a problem existed. Indeed, Britain and France questioned whether the United States was being motivated by economic concerns (the threat of European dominance in commercial supersonic flight) rather than environmental concerns, and were angered by what they saw as U.S. "environmental neocolonialism."29

The Supersonic Transport

Concern over the depletion of stratospheric ozone first centered on the issue of water vapor and nitrogen oxide (NOx) emissions from the proposed high-flying fleet of commercial supersonic aircraft.30 During the 1960s, the Boeing Corporation, with the help of a large federal subsidy, was working on developing a commercial supersonic transport (SST). Similar projects, the joint British/French Concorde and the Soviet TU144, were under way in Europe. In the United States, it was widely believed at the highest level of government and industry that the future of the U.S. aircraft industry as well as the prestige and dominance of U.S. technology rest with the successful development of an SST.31 However, the project was controversial for economic and political reasons, and for other environmental problems (sonic booms and engine noise), long before the issue of stratospheric ozone depletion was raised. It was these other factors (most notably the question of federal subsidy) and not concern for the protection of the ozone layer that killed the U.S. SST program in 1971.32

It was not until 1970 that attention began to focus on the potential destruction of stratospheric ozone from NOx emissions from the SST.33 It was also hypothesized at this time that increased UV-B radiation resulting from a decrease in stratospheric ozone could result in a higher incidence of skin cancer in humans.34 These hypotheses were widely disputed by proponents of the SST, who accused opponents of using unfounded predictions of doom and gloom to scare the public.35

Despite the fact that the U.S. SST program was put on hold in 1971, concern over the SST's potential impact on the stratosphere and on climate remained because Britain and France planned to continue the Concorde program, and the possibility remained that the U.S. program would be revived. As a result, in late 1971 Congress authorized the Department of Transportation (DOT) to investigate the potential environmental impacts of stratospheric flight. The mandate of DOT's Climate Impact Assessment Program (CIAP) was to assess the impacts that a fleet of high-flying SSTs might have on the ozone layer and on climate, to determine what regulatory measures might be necessary to protect the stratosphere, and to report its findings to Congress by 1974.36

CIAP was a major three-year research effort involving over 500 scientists and costing over $20 million. The final output included a report of findings, six monographs, and the proceedings from four international conferences (totaling over 9,000 pages).37 In December 1974, when the conclusions of the project were released to the public and the press through a 23-page Executive Summary35 (before the full report was released), a great controversy erupted.39 Glantz explains that the scientists who had worked on the project objected to the "tone" of the summary, which differed from the tone of the more detailed Report of Findings.40 Many of these scientists charged that DOT's summary distorted their findings and ignored the potential impacts from a large, high-flying fleet of SSTs.

Citing the Executive Summary and related press releases, the media widely reported that concern about adverse environmental impacts from the SST in the stratosphere were unfounded. This was clearly not the conclusion of CIAP, which supported the SST/ozone-depletion theory proposed by Johnston in 1970, and pointed to the potential skin-cancer hazard.41 In addition, a study by the National Academy of Sciences also supported the SST/ozone-depletion theory.42

The debate over the SST in the United States had important implications for the development of the joint British/French Concorde. In order to prove its economic viability, the Concorde needed access to the major U.S. markets. This was not an easy task--to begin with, there were the obvious environmental concerns, but more importantly, there were concerns about long-term U.S. interests in developing an SST. The U.S. decision was to allow access by the original sixteen production models of the Concorde to thirteen U.S. airports, at the option of the airports. According to Ross this was a "highly political compromise" that said that "the Concorde is to be tolerated but not encouraged."43 This decision and the problems that the United States had created in promoting supersonic flight left the British and French with a bad feeling that would later have implications for the CFC issue.44

The debate over developing a commercial SST was important to the issue of CFC-induced stratospheric ozone depletion not only because it identified the potential threat that human activity might pose to the ozone layer, but more generally because it marked the beginning of a period in which technological development would increasingly have to be balanced with other societal goals. Horwitch argues that "the SST conflict was clearly both a catalyst and a harbinger of a new era."45 In this new era, technological development would be greeted with increasing public and political scrutiny, and environmental groups and the public would become key participants in the decisionmaking process.

The Spray-Can Issue

In 1974, as work on CIAP was nearing completion, the issue of CFCs was brought to the attention of the public. It was initially raised as a completely separate issue from CIAP and the SST debate. A principal difference between the SST and the CFC/spray-can issue was that the SST represented a potential threat while CFCs were an actual threat. The initial public debate was polarized between those who predicted catastrophe and those who thought such predictions were absurd. Not surprisingly, both manufacturers and users of CFCs opposed any effort to regulate CFCs in aerosol spray cans. They questioned the validity of the theory, pointing out the uncertainties and noting the lack of supporting evidence.

In the political and public arenas, the CFC/spray can issue was taken seriously. The issue emerged not only against the background of the SST/ozone issue, but also against the background of a rapidly expanding and increasingly powerful environmental movement and growing public concern for and fear of environmental problems. The fear of skin cancer from the depletion of stratospheric ozone due to the use of CFCs as aerosol propellants in spray cans personalized the risks for many people.46 Through the media, the public learned that such nonessential products as aerosol hairsprays and deodorants could pose serious future environmental and health risks.47 The public came to view the risks of using CFC-based aerosols as unacceptable. As a result, even before the aerosol ban of 1978, the sale of aerosol products fell sharply.45 Industry, feeling invulnerable, was not prepared for such a strong public and political reaction.

It was against this background that, in January 1975, an ad hoc Interagency Task Force on Inadvertent Modification of the Stratosphere (IMOS) was established by the National Science Foundation and the Council on Environmental Quality to develop a coordinated plan of action for federal agencies.49 In addition to IMOS, the National Academy of Sciences initiated an even more detailed study of the CFC problem.50 Both studies built upon the work from CIAP and the debate over the SST. Bastian comments that the rapid governmental assessment and response to the CFC issue "would not have been possible without the earlier growth of a corps of scientists and policymakers who knew and cared about the stratosphere."51 It was upon the recommendations of these studies and reports that a policy response would be formulated.

The IMOS report, released in June 1975, while conservative in its assessment, supported the CFC/ozone depletion theory and its link to skin cancer.52 However, rather than endorsing a specific bill to regulate CFCs, IMOS supported the Toxic Substance Control Act (TSCA) that was being debated in Congress. The problem with formulating CFC regulations was that no single agency or law provided a comprehensive framework for implementing and enforcing regulations. Bastian notes that existing authority was "overlapping and incomplete."53 TSCA would solve this problem. IMOS also recommended that if the NAS study supported the findings of IMOS, federal agencies should initiate rulemaking procedures for controlling CFC use.

The NAS study, released in September 1976, supported Molina and Rowland's theory as well as the connection between ozone depletion and the increased incidence of skin cancer.54 The study also noted that existing legislation was inadequate for regulating CFC use and recommended that new legislation be enacted. In addition, the NAS study recommended selective regulation of CFC use if, after a period of further study of no more than two years, the threat of significant ozone depletion remained. With the conclusions of the NAS study in hand, IMOS issued a recommendation that federal agencies initiate rulemaking procedures.55 This was followed by announcements by the appropriate federal regulatory agencies--EPA, Consumer Products Safety Commission (CPSC), and the Food and Drug Administration (FDA)--that they would initiate rulemaking procedures.56

The Aerosol Ban

In October 1976, the Toxic Substance Control Act57 was passed giving the EPA broad regulatory authority over CFCs. In order to facilitate the rulemaking process, a multi-agency work group was formed under EPA's leadership.58 The work group proposed a two-phase effort: the first would focus on regulating nonessential uses of CFCs in aerosols under TSCA, and the second on regulating other uses of CFCs. In May 1977, EPA announced proposed regulations for controlling CFCs in aerosols,59 and in March 1978 final regulations banning the nonessential use of CFCs in aerosols were promulgated by EPA and FDA under TSCA and the Federal Food, Drug and Cosmetic Act.60 The ban took effect in December 1978.

In addition to TSCA, the 1977 amendments to the Clean Air Act61 provided the EPA with an even broader mandate for protecting the stratosphere. Under the Clean Air Act Amendments, the EPA is required to regulate any activity that threatens the stratosphere and endangers public health.62 Despite this mandate and the goal for phase two of the multiagency work group, however, no action was taken to regulate non-aerosol CFC uses. The multi-agency work group argued that with little interest and cooperation in regulating CFCs outside the United States, regulation of other uses of CFCs was not "viable."63 However, other uses of CFCs, such as refrigeration, could not easily be described as nonessential, and the argument for readily available substitutes for non-aerosol uses of CFCs was not as strong. In addition, the chemical industry, reeling from the aerosol defeat, persuasively argued that time was needed to develop substitutes.64

The United States was not the only country to ban the use of CFCs in aerosols, although it was the only major producer/user to do so. Canada, Sweden, Norway, and Denmark also banned the use of CFCs in aerosols; the Netherlands (a major producer/user of CFCs) required warning labels on aerosol spray cans; and in West Germany (another large producer/user of CFCs) industry agreed to a one-third reduction in CFC use in aerosols.65 In addition, in 1980 the European Economic Community (EEC) required member nations not to increase CFC production and to reduce CFC use in aerosols by 30 percent from 1976 levels by the end of 1981; this act was mostly symbolic, since aerosol use in Europe had already declined significantly from 1976 levels, and European production was far below capacity. 66

The greatest resistance to CFC regulations came from France and Britain, both major producers and users of CFCs, but both countries eventually adopted the EEC regulation for a 30 percent reduction in aerosol uses of CFCs. Downing and Kates argue that the reluctance of France and the Britain to regulate CFCs was due partly to the potential economic impact, the nature of their environmental decisionmaking process, and the fact that they were involved in developing a commercial SST.67 With the memory of the Concorde still fresh, the British and French were skeptical of U.S. motivations.68 In addition, the European countries in general were less inclined to take the threat seriously and to regulate CFCs without conclusive scientific evidence linking CFCs with ozone depletion.69

In summary, the process of formulating a policy response to CFC-induced stratospheric ozone depletion in the United States can be assessed as a three-step process: (1) assessment of the problem and the risks; (2) development of a regulatory authority; and (3) formulation and implementation of a regulation. By 1978, the issue of stratospheric ozone depletion had progressed through all of these steps. The action taken by the United States was both significant and remarkable. It had taken less than five years to move from the scientific discovery of a potentially serious environmental problem to the implementation of a major new regulation designed to resolve that problem.

STAGE II: OZONE DEPLETION AS AN INTERNATIONAL ISSUE

While ozone depletion had emerged as a major environmental policy issue in the United States and several other countries by the late-1970s, the issue was by no means resolved. Among the major CFC producer/user nations, only the United States had taken substantial action, and then only concerning CFC use in aerosols. Ozone depletion was a global problem, and it was becoming increasingly clear that an effective response would have to be international. Between 1977 and 1985, the problem of stratospheric ozone depletion moved from the national to the international political arena. In 1985, the Vienna Convention70 legitimized stratospheric ozone depletion as an international political issue, and provided the framework under which the Montreal Protocol would be negotiated. Yet final agreement in Montreal would require more than an emerging international consensus.

UNEP and International Negotiations

Stage II, the process of formulating an international response, had begun even before the U.S. aerosol ban in 1978. In addition to research and regulatory efforts by the United States and other countries, several international organizations became involved in the CFC/ozone issue in the mid-1970s, including UNEP, the World Meteorological Organization (WMO), the Organization for Economic Cooperation and Development (OECD), and the EEC. UNEP in particular has played a central role in coordinating international research efforts and in developing an international response to the CFC/ozone problem, especially in terms of problem recognition and assessment, and the identification of policy alternatives.71

Many of the early efforts of UNEP and the other international organizations were aimed specifically at coordinating international research. For example, a WMO statement from a 1975 meeting of experts on stratospheric ozone stated the need for a coordinated international effort to monitor and study stratospheric ozone and the need for collaboration with other international organizations such as UNEP and the International Council of Scientific Unions (ICSU).72 in 1976, the Governing Council of UNEP adopted a decision requesting that the executive director convene an international meeting on stratospheric ozone.73 This meeting was held in March 1977 in Washington, D.C. and assessed current research and future research needs.74 A second international meeting in April 1977, sponsored by EPA, assessed measures for protecting the ozone layer.75

At UNEP's 1977 meeting, a World Plan of Action for the Ozone Layer was adopted. The plan outlined research needs in three areas: (1) the natural ozone layer; (2) impact of changes in the natural ozone layer; and (3) socio-economic aspects.76 It also recommended that UNEP exercise a "coordinating and catalytic role" in implementing the plan by establishing a Coordinating Committee on the Ozone Layer (CCOL). CCOL, whose membership includes representatives from national and international agencies and from nongovernmental organizations, has been meeting regularly since 1977. It assesses recent research results and data on impacts, makes recommendations relevant to implementing the World Plan of Action, and publishes the Ozone Layer Bulletin.

In addition to its efforts at coordinating research, UNEP took on a second task: in May 1981, the governing council of UNEP formed an ad hoc legal and technical working group to draft a Global Framework Convention for the Protection of the Ozone Layer.77 The result was the "Vienna Convention for the Protection of the Ozone Layer," adopted at a conference of 43 states in March 1985, which outlined the responsibilities of states to protect "human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer."78 The convention also called for international cooperation in research, monitoring, and information exchange. It was designed as an "umbrella treaty" to be supplemented by more specific protocols and subtreaties.79 While an effort made to include a protocol on controlling CFC production and use with the convention failed, a Resolution on a Protocol Concerning Chlorofluorocarbons was adopted, calling for "a protocol to control equitably global production, emissions and use of CFCs."80

No protocol on controlling CFC production and use was adopted at the Vienna Convention because of a dispute between the United States, Canada, Sweden, Norway, and Finland (often referred to as the Toronto Group) on one side and the EEC countries on the other. The EEC favored a production capacity cap and a 30 percent cut in nonessential aerosol use of CFCs, while the United States, Canada, and the Scandinavian countries (which had already banned nonessential aerosol use of CFCs) favored an 80 percent reduction or a complete ban in nonessential aerosol use of CFCs. The dispute centered on the fact that the Toronto Group countries had already banned aerosol use of CFCs while the EEC countries had not. Furthermore, the EEC countries were only producing at 65 percent of capacity and thus could still significantly increase production despite a capacity cap. The Toronto Group sought controls that would force the European countries to cut back on aerosol use of CFCs, while the EEC opposed being forced to adopt regulations already adopted by the Toronto Group countries. The dispute polarized the negotiations.81

The Vienna Convention was important because it represented a common ground on which international consensus had been reached, and also established the framework under which a protocol would be negotiated. Subsequently, the key question was not so much whether there would be a protocol, but rather how strong it would be.

THE ROAD TO MONTREAL

In 1986 and 1987 a new sense of urgency about stratospheric ozone emerged as a result of several key events. First, there was the rapid growth in demand for CFCs with the end of the global economic recession. Demand for CFCs had been growing at five percent annually since 1983, and in 1986 it had reached levels that existed in the mid-1970s before action was taken to regulate aerosol uses of CFCs.82 In addition, in 1983, President Reagan's first EPA Administrator, Anne Gorsuch, who had not favored further CFC regulation, resigned. Under new leadership, EPA rejuvenated its stratospheric ozone program.83 Also, in conjunction with its 1980 Advance Notice of Proposed Rulemaking concerning nonaerosol uses of CFCs, EPA was facing a lawsuit from the Natural Resources Defense Council designed to force EPA to take action to protect stratospheric ozone under the Clean Air Act.84 There were also important new studies by WMO/NASA and EPA/UNEP.85 Finally, in 1985 scientists discovered the Antarctic ozone hole, an event which received much media attention. 86

In January 1986, EPA announced its new Stratospheric Ozone Protection Plan. The plan was based on organizing a series of domestic and international workshops to develop and assess information on CFCs and stratospheric ozone to be used in upcoming international negotiations and for domestic rulemaking.87 These workshops were critical in building an international consensus on the need for measures controlling CFC production and use. The plan also called for EPA to undertake a risk assessment which would be used to guide future decisionmaking.88 The United States now had a strong program to shape U.S. and international policy on CFCs and stratospheric ozone depletion.

In December 1986, negotiations on a protocol to the Vienna Convention for controlling CFCs resumed. The new U.S. position, as outlined by EPA and the State Department, called for a near-term freeze on the production of CFCs and halons and a long-term phaseout. In February 1987, the United States called for freezing CFCs and halons at 1986 levels and then cutting back by 95 percent in 10-14 years.89 Richard Benedick, Deputy Assistant Secretary of State and chief U.S. negotiator in Montreal, and EPA Administrator Lee Thomas were instrumental in formulating the U.S. position, and promoting it both within the United States and internationally. The U.S. position was based on new research that pointed to a strong and growing consensus in the international scientific community concerning the serious threat that CFCs posed to the ozone layer,90 and on the recent EPA risk assessment that demonstrated that unacceptable risks were associated with ozone depletion.91

The European countries indicated that there was flexibility in their earlier position. At first they favored only a freeze. However, by February 1987, they agreed to a 20 percent cut,92 and by that spring there was consensus on the need for a 50 percent reduction.93 The shift in the European position came about through difficult negotiations.94 The Europeans were also convinced by the weight of recent scientific assessments. In addition, European governments were being pressured by their own environmental groups, and the EEC countries, as well as Japan, feared that if there was no international agreement, the United States might take unilateral action and impose trade sanctions. An international agreement was also considered by all parties, including industry, as a powerful incentive for developing and marketing CFC substitutes.

In the spring of 1987, however, as negotiations on a protocol continued, a serious rift developed within the U.S. administration. Opposition came from within the Office of Management and Budget, and the Departments of Commerce, Energy, and Interior, which supported only a CFC production/use freeze.95 It has also been suggested that these agencies were disturbed by the failure of EPA and the State Department to keep other agencies fully informed on the rapidly evolving U.S. position, particularly at the highest levels.96 It may be, however, that these agencies were fully informed, and that in fact they were simply surprised by the success of the EPA/State Department negotiations on the Protocol.

This split in the Reagan Administration received considerable publicity. For example, when Secretary of the Interior Hodel suggested that wearing hats and sunglasses and using sunscreen was an effective way to mitigate the potential health effects of increased UV-B radiation, the story was widely covered by the news media. At one point it appeared as if the U.S. position would be significantly weakened, but the Senate overwhelmingly passed a resolution supporting a 50 percent reduction and eventual phaseout of CFCs, and Hodel's remarks as well as proposals to weaken the U.S. position received much criticism in the press.97 Eventually President Reagan's decision was to favor a 50 percent reduction in CFCs and a freeze in halons (the eventual structure of the protocol). Despite the last-minute reassessment of the U.S. position, the United States remained the principal advocate for a strong protocol. The United States, EPA, and the State Department in particular, deserve much credit for the strength of the Montreal Protocol.

THE BASIS FOR AGREEMENT: THREE CRITICAL FACTORS

The Montreal Protocol was an outgrowth of the 1985 Vienna Convention, which legitimized stratospheric ozone depletion as an international environmental issue and established the basis for negotiation that would eventually lead to the protocol. However, other factors critical to building international consensus on the need for substative measures controlling global production and use of CFCs were not fully in place in 1985. These factors were: (1) the evolving scientific understanding of stratospheric ozone and its influence on policymaking; (2) increasing public concern based on the threat of skin cancer and the perception of potential global catastrophe associated with the discovery of the Antarctic ozone hole; and (3) the availability of acceptable substitutes. It was the evolution of these factors that finally opened the door to the Montreal Protocol.

Evolving Science

The evolving scientific understanding of stratospheric ozone was a key factor in reaching agreement on a protocol. While there was considerable disagreement among scientists over the problem of stratospheric ozone depletion in the 1970s, improvements in the collection and assessment of data and in models in the past decade have led to the development of a stronger scientific base on which to argue for and develop control strategies. Major scientific assessment projects have continued to point to and elaborate on the threat that CFCs posed to atmospheric ozone. Two reports were particularly important and influential. The first was the 1985 WMO/NASA international assessment on the processes controlling atmospheric ozone. This three-volume work involved 150 scientists from eleven countries and demonstrated a strong and growing consensus on the threat that CFCs posed to atmospheric ozone.98 In summarizing this report, Watson et al. conclude that:

there is now compelling observational evidence indicating increases in the concentrations of gases which control atmospheric ozone. These gases, which include the chlorofluorocarbons, . . . are the precursors to the hydrogen, nitrogen, and chlorine oxides which catalyze the destruction of ozone in the stratosphere.99

In addition, in June 1986, EPA and UNEP jointly sponsored an international conference and report on the effects of changes in stratospheric ozone and global climate.100 The conference brought together 300 scientists and policymakers from 20 nations and produced a four-volume report.101 The June EPA/UNEP conference was followed in September by an international workshop sponsored by the United States and held in Leesburg, Virginia. This workshop was part of the process of negotiating a protocol as outlined by the resolution to the Vienna Convention. Building upon the work of the earlier UNEP/EPA report and the WMO/NASA assessment, the Leesburg workshop was instrumental in achieving a consensus among the principal negotiating parties on the need for CFC controls. 102

The importance of these scientific reports was two-fold. First, they demonstrated a strong international consensus among scientists and policymakers that CFCs posed a serious threat to the ozone layer, that the problem was global in scope, and that society would have to deal with the effects for decades, if not centuries. Second, this research demonstrated the connections between ozone depletion and global warming. Not only were CFCs an important greenhouse gas, but the effective redistribution of atmospheric ozone (the decrease in the middle and upper stratosphere and the increase in the lower atmosphere) would also contribute to global warming. Thus the emerging consensus was that the two issues, ozone depletion and global warming, should be considered together. 103

In addition to these studies, EPA, through its Stratospheric Ozone Protection Plan, undertook a massive assessment of the risks posed by trace gases that can modify stratospheric ozone. This risk assessment concluded that:

current scientific theory and evidence indicate that continued increases in the concentrations of a variety of trace gases in the atmosphere are likely to modify the vertical distribution and column abundance of stratospheric and tropospheric ozone . . . and consequently affect public health and welfare. 104

The EPA risk assessment also made some staggering assessments of potential effects. For example, using a scenario of no CFC controls and a continued annual growth of 2.5 percent through 2050, EPA estimated over 150 million additional skin cancer cases, resulting in more than three million deaths for the U.S. population born before 2075.105

EPA and the State Department based the U.S. position of a near-term freeze and eventual long-term phaseout of CFCs on the risk assessment and the other scientific studies. These studies also had considerable influence on European policymakers and on the chemical industry. The most current scientific research was conclusively pointing to the role of CFCs in depleting atmospheric ozone, and the serious threat that this posed to the global environment and the health and welfare of people in all nations.

Catastrophic Nature of the Risks: The "Dread Factor"

The public's perception of the risks from an environmental problem can have a significant effect on how policymakers respond to that problem.106 Slovic et al. have identified a shared set of characteristics called "dread" that help explain how the public perceives risks from certain technologies and hazards.107 The risks from a technology or hazard that are perceived to be high in dread are those that are seen to be globally catastrophic, threatening to future generations, increasing, hard to prevent, not easily reduced, involuntary, and personally threatening. Technologies and hazards that score high in dread include among others nuclear power, nuclear weapons, DDT and other pesticides, liquid natural gas, and asbestos. A second important factor is familiarity, that is, whether the risks are observable, known to those exposed and to the scientific community, and whether the effects are immediate or delayed. A third factor is the extent of exposure. Risks from technologies such as nuclear power or DDT that are perceived to be high in dread, low in familiarity, and high in exposure are more likely to be seen as unacceptable by the public.108

The CFC/ozone-depletion problem shares many of these characteristics. In particular, the increased risk of skin cancer is a global problem which is threatening to future generations, increasing, hard to prevent, and not easily reduced. Furthermore, exposure is involuntary and personally threatening. In addition, the recently discovered ozone hole over Antarctica109 has likely contributed greatly to the perception of global catastrophe and dread, adding a new sense of urgency. Also, familiarity with the ozone depletion problem is low: the risks are not easily observable, and they are delayed and not well understood by scientists. In other words, the risks associated with ozone depletion are high in dread, low in familiarity, and high in exposure. The problem is global, with a potential for catastrophic impacts on human health and the environment, and it is not well understood by the public or scientists.

The dread and unacceptable nature of the risks associated with stratospheric ozone depletion have undoubtedly contributed to maintaining political interest in the problem and the search for a solution. The well-documented risk of increased skin cancer110 has long been a driving force behind efforts to protect the ozone layer: it was central to the SST/ozone depletion debate, and it was the principal reason for the U. S . aerosol ban in 1978.

It is more difficult to identify the exact role that the Antarctic ozone hole played in reaching an international agreement in Montreal. During the time the protocol was being negotiated, the cause of the Antarctic ozone hole had not been clearly identified. While many scientists suspected CFCs, this had not been proven. Thus it was dangerous to use the ozone hole as an argument for the protocol. It was necessary to base the protocol on established scientific consensus. Thus if some other cause than CFCs was found for the ozone hole, this could not be used to reconsider the protocol. Nevertheless, regardless of its exact cause, the Antarctic ozone hole represented a tangible impact. It could be detected and recorded by satellites. As a powerful symbol of the potential impacts from stratospheric ozone depletion, the ozone hole galvanized world opinion, and thus influenced the outcome in Montreal.

Industry and the Search for Substitutes

In the 1970s, producers and users of CFCs in the United States waged a long, hard battle against the regulation of CFCs.111 While industry was unable to prevent the regulation of CFC use in aerosols, they did prevent EPA from proposing regulations regarding non-aerosol uses of CFCs. Likewise in Europe and Japan, industry was strongly opposed to regulating CFCs. Industry argued that there was simply no proof that CFCs were harmful to stratospheric ozone.

By 1986, U.S. industry's opposition to CFC regulation had softened considerably. The increasing worldwide demand for CFCs, coupled with the growing scientific evidence on the role of CFCs as both an ozone depleter and a greenhouse gas, and the realization that some type of international agreement regulating CFCs would be adopted, forced industry to re-evaluate its position.112 In the fall of 1986, the Alliance for Responsible CFC Policy, an industry lobby group, endorsed a position favoring a "reasonable" global limit on the growth of CFC production capacity. DuPont, the world's largest producer of CFCs with 25 percent of the global market, took an even stronger position, calling for a worldwide limit on CFC emissions; however, DuPont did not specify what this limit should be.113

Clearly DuPont was motivated by the same factors that brought about the shift in industry position in general. However, the CFC industry, and DuPont in particular, were also looking at the possibility of developing substitutes. The chemical industry had been working on developing new chemicals such as CFC-123 and -134a which decomposed in the troposphere and could be used as substitutes for CFC-11 and -12. The development of these substitutes, however, was controlled not only by chemistry, but also by the market. DuPont, in fact, announced that suitable alternatives could be available within five years given the right market conditions.114 Thus the development of alternatives was dependent on economic and regulatory incentives to do so. An international protocol was seen by industry as a useful mechanism for providing the necessary economic incentive to develop and market suitable alternatives.

Thus the debate shifted from whether regulation was necessary to when and how to regulate. Yet industry was opposed to a complete phaseout of CFCs, favoring instead a freeze or a limit on future production and an emissions tax. Most important, however, industry stressed the need for a regulatory structure that allowed for a smooth transition period.115 This shift in position was a major step in reaching agreement on the Montreal Protocol.

THE MONTREAL PROTOCOL

The Montreal Protocol, the result of nearly 15 years of political and public concern over the impact of CFCs on the ozone layer, outlines specific measures and timetables for reducing production and consumption of CFCs and halons.116 The protocol divides ozone-depleting compounds into two groups. Group I includes the fully halogenated CFCs (CFC-11, -12, -113, -114, and -115) which are the most threatening to the ozone layer, and Group II includes the halons. The protocol also makes an important distinction between developed countries and developing countries, which are referred to as "Article 5 countries" in the protocol. The difference between the developed countries and the Article 5 countries concerns the timing of the production and consumption reductions.

For the developed countries, the protocol stipulates that the production and consumption of Group I compounds are to be frozen at 1986 levels beginning in 1989. Production and consumption of Group I compounds must be reduced to 80 percent of 1986 levels by 1994, and 50 percent of 1986 levels by 1999. The protocol, however, permits a 10 percent (15 percent after 1998) increase in production over the prescribed levels if the additional production is for export to Article 5 countries, or to be used for industrial rationalization (the transfer of production) between parties. The protocol stipulates that the production and consumption of Group II compounds are to be frozen at 1986 levels by 1993. For the Article 5 countries, the same restrictions apply concerning Group I and II compounds, but with a ten-year delay in implementation. Article 5 countries can continue to increase production and consumption until 1999 as long as per capita consumption does not exceed 0.3 kilograms. An average of each Article 5 country's consumption between 1995 and 1997 will be used as the reference level for the staged reductions that take effect in 1999.

The protocol also requires parties to ban the import of ozone-depleting products from nonparties, and to "discourage" the export of technologies used in producing and utilizing ozone-depleting substances to nonparties. Finally, the Montreal Protocol is a flexible agreement; it includes mechanisms for re-evaluating and revising the protocol on the basis of new scientific information beginning in 1990.117

The Montreal Protocol entered into force as scheduled on January 1, 1989. Conditions for entry into force included the ratification of the protocol by at least 11 countries representing two-thirds of the global consumption of CFCs and halons controlled under the protocol, and the entry into force of the Vienna Convention. The Vienna Convention was ratified in June 1988, and the ratification requirements for the Montreal Protocol were met in December 1988. By May 1989, 36 countries had ratified the protocol.

Despite the landmark achievement that the Montreal Protocol represents, it is not a perfect document. While the provisions outlined in the Protocol have the potential to greatly slow the rate of production and consumption of CFCs and halons, they may not necessarily prevent the continued depletion of the ozone layer. It is difficult to assess the eventual impact of the Montreal Protocol on CFC and halon production and consumption since there are unresolved issues and ambiguities in the protocol that make exact interpretation difficult.118

The Congressional Office of Technology Assessment (OTA) has made a study of the potential impacts of the protocol on global CFC and halon production and consumption, noting that the success of the protocol is dependent on a number of factors, including the number of countries that ratify the protocol, the extent to which countries comply with the protocol, and the amount of growth in CFC and halon consumption in Article 5 countries.119 Furthermore, it is possible that additional control provisions could be added to the treaty, or that the consumption of CFCs and halons could drop even further than prescribed in the protocol as suitable alternatives are developed.

Taking these uncertainties into account, OTA has estimated that if every nation signs the treaty, CFC and halon consumption could decline by as much 45 percent by 2009, but if only the countries that originally signed the protocol comply with its provisions, consumption of CFCs and halons could increase by as much as 20 percent.120 If the treaty never goes into force, OTA estimates that CFC and halon production could increase 110 to 140 percent. Yet even with a 45 percent decrease in CFC and halon consumption, ozone depletion will not be prevented. EPA, for example. has estimated that an 80 percent reduction in CFC-11 and -12 consumption is needed to prevent the atmospheric concentration of CFCs from increasing further.121 Furthermore, recent scientific evidence has indicated that CFCs are already responsible for a 1.7 to 3.0 percent reduction in ozone over the mid-latitudes in the northern hemisphere; CFCs have also been identified as being at least partly responsible for the Antarctic ozone Thus even the present atmospheric concentration of CFCs threatens the ozone layer.

Environmental groups have also questioned whether the protocol is adequate.123 Recently, with the findings of the Ozone Trends Panel, there has been a call for strengthening the protocol so as to completely phase out CFCs. Whether this will happen is uncertain, however, review of the protocol has already begun. The immediate goal remains implementation of the protocol. The United States has taken major steps toward this goal. In December 1987, EPA proposed new regulations that are in accordance with the Montreal Ptotocol,124 and in March 1988 the U.S. Senate unanimously ratified the protocol, making the United States the second country to ratify the protocol. Environmental groups, however, contend that the United States must do more, arguing for stronger EPA regulations and an active role for the United States as an international lobbyist for protecting the ozone layer.125

Perhaps the real measure of success for the protocol is how well it works as an incentive to develop economical and environmentally safe alternatives to CFCs and halons. Recently, DuPont announced plans to phase out its production of CFC by the end of the century. DuPont claims that this decision was based on the Ozone Trends Panel's (1988) report, which attributed ozone reductions in the northern hemisphere to CFCs. DuPont cited this work as the first conclusive evidence connecting CFCs with ozone depletion.126 Regardless of what motivated DuPont to phase out CFCs, their action will likely effect other CFC producers, providing even more incentive to develop substitutes.

CONCLUSION

The history of the ozone issue illustrates the emergence, persistence, and evolution of the fate of stratospheric ozone as both a national and an international political issue. The evolution of stratospheric ozone policy over the past two decades can best be understood as a two-stage process. Stage I focuses on the emergence of stratospheric ozone depletion as an environmental and political issue primarily in the United States, while stage II involves the transformation of stratospheric ozone depletion from a national to an international issue in the 1980s. However, three additional factors were critical in achieving final agreement on the need for international action to reduce global production and consumption of CFCs: (1) the evolving scientific understanding of stratospheric ozone and its role in building an international consensus that a real problem existed; (2) the role of the threat of skin cancer and, since 1985, the role of the Antarctic ozone hole in galvanizing world public opinion; and (3) the fact that industry foresaw the availability of effective substitutes in the near future.

If stage I of the process of formulating stratospheric ozone depletion policy is compared with stage II, it can be seen that these key factors were significantly different between the two stages. In stage I, CFC-induced depletion of stratospheric ozone was principally a domestic issue within the United States; in stage II it had become an international issue. In stage I, there was little consensus among the principal actors on the nature and scope of the problem; in stage II, based on strong scientific evidence, consensus on the nature and scope of the problem was reached. In stage I, the public was reacting to the potential threat of skin cancer; in stage II, they were reacting not only to the potential threat of skin cancer but also to the reality of the Antarctic ozone hole. Finally, in stage I, industry argued that substitutes for non-aerosol uses of CFC did not exist; in stage II, industry not only admitted that it would be possible to develop effective substitutes, they also viewed the protocol as a necessary measure to spur development of these substitutes.

Decisionmakers are confronted with great difficulty when making decisions about cumulative low-grade, long-term environmental problems where impacts are often delayed by decades or even centuries.127 They often choose to ignore them rather than deal with them. The existence of the Montreal Protocol then is encouraging because decisionmakers decided to take significant action--reducing the emissions of important chemicals--more on the basis of the theory that CFCs destroyed ozone than on conclusive evidence that ozone was actually being depleted by CFCs. However, the scientific evidence behind the theory was substantial and there was strong preliminary evidence pointing to ozone depletion by CFCs. Decisionmakers, based on an assessment of the problem, found the risks unacceptable. Yet the actual decisionmaking process was not quite this simple. There were other important motivating factors. For example, industry needed regulation to spur its development of alternatives and the public responded to the problem with great concern. However, perhaps most important, over 15 years the issue of ozone depletion had evolved as a political issue, and had been transformed from a national environmental and political issue to an international one. In a sense then, in September 1987 the time was right to act, as the scientific evidence was more conclusive than ever and the social, economic, and political climate had evolved sufficiently.

While the Montreal Protocol is not a perfect document, it is nevertheless a landmark agreement. It is the first international agreement aimed at resolving a global atmospheric problem. It is important not only because it outlines measures agreed on by the international community to protect the ozone layer, but also because it signifies that innovative approaches to major global environmental problems are possible. Yet the world should not be lulled into a false sense of security by the protocol: the protocol may not solve the ozone depletion problem, at least in the near term. In addition, while there are certainly similarities between ozone depletion and other global environmental problems such as global warming, the means for dealing with these other problems may not be the same as for ozone depletion. The Montreal Protocol, however, offers the precedent of international negotiation and agreement on global environmental problems.

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98. Atmospheric Ozone, supra note 4.

99. R. Watson, M. Gelle, R. Stolarski & R. Hampson, supra note 4, at xi.

100. Stratospheric Ozone and Climate, supra note 7.

101. Id.

102. See R. Benedick, supra note 44.

103. R. Watson, M. Gelle, R. Stolarski & R. Hampson, supra note 4.

104. EPA, supra note 7, at 1.

105. EPA, supra note 7.

106. See I. Burton, R. Kates & G. White, The Environment As Hazard (1978); Slovic, Fischhoff & Lichtenstein, supra note 46; R. Kates, C. Hohenemser & J. Kasperson, Perilous Progress (1985).

107. Slovic, Fischhoff & Lichtenstein, supra note 46.

108. Id.

109. For a discussion of the Antarctic ozone hole, see Farmer, Gardiner & Shanklin, supra note 19 and Rowland, supra note 22.

110. See NRC, supra note 9; Emmett, supra note 9; EPA, supra note 7.

111. See L. Dotto & H. Schiff, supra note 29.

112. Response to Ozone Depletion, supra note 82, at 47.

113.1d. at 48-49.

114. Id. at 52.

115. See id. at 48-53.

116. Montreal Protocol on Substances that Deplete the Ozone Layer, supra note 1.

117. The process of re-evaluating and revising the protocol has already begun. Data from scientific work in Antarctica in 1987 linking the ozone hold to CFCs (see Kerr, supra note 23), and the 1988 Ozone Trends Panel Report which linked CFCs to ozone depletion in the northern hemisphere

midlatitudes (see NASA Ozone Trends Panel, supra note 4) provided the scientific evidence necessary for beginning the process of re-evaluation. It now appears likely that the protocol will be revised, calling for an 85 percent reduction in the production and consumption of CFCs, rather than the 50 percent reduction currently prescribed in the protocol. See Dickson & Marshall, Europe Recognizes the Ozone Threat, 243 Science 1279 (1989); McGourty, London Ozone Meeting Wins Some Hearts, 338 Nature 101 (1989).

118. Congressional Office of Technology Assessment, An Analysis of the Montreal Protocol on Substances That Deplete the Ozone Layer (rev. Feb. 1988) (Staff Paper).

119. Id

120. Id. at 5-9.

121. Titus & Seidel, Overview of the Effects of Changing the Atmosphere, in 1 Stratospheric Ozone and Climate, supra note 7, at 3; Hoffman, The Importance of Knowing Sooner, in 1 Stratospheric Ozone and Climate, supra note 7, at 53.

122. NASA Ozone Trends Panel, supra note 4.

123. See Doniger, supra note 82.

124. Protection of Stratospheric Ozone, 52 Fed. Reg. 47,489 (1987) (to be codified at 40 C. F. R. Part 82) (proposed Dec. 14, 1987).

125. See Doniger, supra note 82.

126. See N.Y. Times, Mar. 26, 1988, at 41, col. 2; Monastersky, Decline of the CFC Empire 133 Science News 234 (1988); Jones, In Search of the Safe CFCs, New Scientist, May 26, 1988, at 56: DuPont Backs `Orderly Transition' to Total Phase-Out of Halogenated CFCs, BNA Env't Rep, Apr. 1, 1988, at 2388.

127. See Glantz, A Political View of CO2, 280 Nature 189 (1979); Glantz, Politics and the Air Around Us, in Societal Responses to Regional Climatic Change: Forecasting by Analogy 41 (M. Glantz ed. 1988).