Framing Science: Precautionary Discourse and the Ozone Treaties

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> We must not imagine that the world turns a readable face towards us, that we only have to decipher; the world is not in concert with our knowledge.[1]

The three dominant theoretical approaches to world politics in recent years—neorealism, institutionalism, and Marxism—define goals and interests in terms of objective material conditions. By contrast, reflectivist approaches see policy-making not just as a mechanical pushing and pulling of nation-states and their agents around externally-determined interests, but rather as a fundamentally intersubjective activity.[2] The epistemic communities literature, which advances the reflectivist agenda by elucidating the impact of knowledge claims on interest formation, represents an important step forward.[3] Epistemic communities are defined as networks of experts who share not only a common policy enterprise, but also specialised knowledge about causal relationships and validity tests.[4] Unlike interest groups, their power derives from their perceived ability to make authoritative knowledge claims. Under conditions of uncertainty, it is argued, epistemic communities may become catalysts for regime formation either through persuasion or by taking control of decision-making channels. Epistemic communities are credited with responsibility for regimes on a range of issues,

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1. Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York, NY: Pantheon Books, 1971), p. 46.

2. For a sampling of reflectivist literature, see Alexander Wendt, 'Anarchy Is What States Make of It: The Social Construction of Power Politics', *International Organization* (Vol. 46, No. 2, 1992), pp. 391-425; Nicholas Onuf, *World of Our Making: Rules and Rule in Social Theory and International Relations* (Columbia, SC: University of South Carolina Press, 1989); Robert O. Keohane, 'International Institutions: Two Approaches', *International Studies Quarterly* (Vol. 32, No. 4, 1988), pp. 379-96; and Friedrich V. Kratochwil, *Rules, Norms, and Decisions: On the Conditions of Practical and Legal Reasoning in International and Domestic Affairs* (Cambridge: Cambridge University Press, 1990).

3. See the special issue of *International Organization* on epistemic communities, *Knowledge, Power, and International Policy Coordination* (Vol. 46, No. 1, 1992).

4. Peter Haas is a leading advocate of an epistemic communities approach. See Peter Haas, 'Introduction: Epistemic Communities and International Policy Coordination', *International Organization* (Vol. 46, No. 1, 1992), pp. 1-36.

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including nuclear arms control, trade in services, food aid, international banking, and stratospheric ozone depletion.[5]

A key problem with the epistemic communities approach lies in the relationship between knowledge and power. Most writers on epistemic communities defend the notion that reality is socially constructed, based not on raw data but on interpretations, but tend to sidestep the *discursive* dimensions of knowledge. If reality is socially constructed, then it must be constructed through the primary medium of social exchange: language. This article proposes that the epistemic communities approach should be supplemented with an attentiveness to the ways in which discursive practices promote specific narratives about social problems. Whereas an epistemic communities approach emphasises agents of information, a discursive approach stresses frameworks of meaning.

The single theme that unites the profusion of schools of discourse analysis, emanating from fields as disparate as linguistics, social theory, and literary criticism, is the notion of language as social interaction.[6] The coherence of discourse cannot be understood if attention is limited to linguistic form and meaning. Rather, linguistic forms and meanings work together with social meanings and interpretive frameworks to create discourse. My own understanding of discourse derives from the work of Michel Foucault, whose major contribution has been to elucidate the radical entanglement of knowledge and power involved in discourse.[7] As Michael Shapiro and his colleagues have shown, a discursive approach involves an epistemological shift away from the conventional separation of subject and object (decision-maker and decision-situation), towards an emphasis on competing knowledgeable practices.[8] Discourses entail, but are not reducible to, interpretations. Rather, they are broader sets of linguistic practices embedded in networks of social relations and tied to narratives about the

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5. The *International Organization* special issue, *op. cit.*, in note 3, included analyses of these various issue areas. See Emmanuel Alder, 'The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control', pp. 101-45; William J. Drake and Kalypso Nicolaidis, 'Ideas, Interests and Institutionalization: Trade in Services and the Uruguay Round', pp. 37-100; Raymond F. Hopkins, 'Reform in the International Food Aid Regime: The Role of Consensual Knowledge', pp. 225-64; G. John Ikenberry, 'A World Economy Restored: Expert Consensus and the Anglo-American Postwar Settlement', pp. 289-321; Peter Haas, 'Banning Chlorofluorocarbons: Epistemic Community Efforts to Protect Stratospheric Ozone', pp. 187-224; and James K. Sebenius, 'Challenging Conventional Explanations of International-Cooperation-Negotiation Analysis and the Case of Epistemic Communities', pp. 323-65.

6. An accessible introduction to discourse analysis is Deborah Schiffrin, *Approaches to Discourse* (Oxford: Blackwell, 1994).

7. See Michel Foucault, *Power/Knowledge: Selected Interviews and Other Writings, 1972-77* (New York, NY: Pantheon Books, 1980).

8. Michael Shapiro, G. Matthew Bonham, and Daniel Heradstveit, 'A Discursive Practices Approach to Collective Decision-Making', *International Studies Quarterly* (Vol. 32, No. 4, 1988), pp. 379-419. This approach is consistent with the structurationist view that social structures and agents are mutually constitutive.

construction of the world.[9] As determinants of what can and cannot be thought, discourses define the range of policy options and operate as resources which empower certain actors and exclude others. They also serve as sites of resistance, fomenting the emergence of counter-discourses.[10]

Paradoxically, Peter Haas is careful to differentiate the epistemic communities approach from discursive approaches, apparently unaware of the extent to which the former necessarily entails the latter.[11] The one real difference he finds between epistemic communities and discursive approaches is that the primary actors are clear for the former and unclear for the latter. Perhaps Haas is correct to rebel against those poststructuralists who, rejecting the notion of social agency altogether, make discourses into free-floating entities, independent of real people and real things.[12] Not surprisingly, their work has rarely been applied to serious policy analysis. On the other hand, the epistemic communities approach might be accused of having an excessively agent-centred meta-theoretical stance. Since social structures and agents are always mutually embedded,[13] discourses should be understood as structuring the policy *milieu* of epistemic communities linguistically and cognitively, particularly in knowledge-driven areas like the environment. However, a discursive approach should not pretend that social agents are either nonexistent or unimportant, despite the language of some poststructuralists. Without agents promoting them, identifying with them, and struggling over them, discourses could not exist; but agents do not act autonomously, wielding the power of discourse on behalf of transparent interests.

Therefore, information, once produced, must be interpreted by agents. This is the work of '*knowledge brokers*'; a term which, unlike *epistemic communities*, highlights the discursive nature of knowledge.[14] Their most important asset is their flair for translating science, often with a 'spin', into language accessible to

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9. As Deborah Stone argues, two generic narratives dominate the policy realm: the story of decline and/or improvement, and the story of control. Deborah A. Stone, *Policy Paradox and Political Reason* (New York, NY: Harper Collins, 1988), pp. 108-26.

10. On discourses as sites of resistance, see Richard Terdiman, *Discourse/Counter-Discourse: The Theory and Practice of Symbolic Resistance in Nineteenth-Century France* (Ithaca, NY: Cornell University Press, 1985). On the social construction of science, see Bruno Latour and Steve Woolgar, *Laboratory Life: The Social Construction of Scientific Facts* (Beverly Hills, CA: Sage, 1979).

11. Haas, *op. cit.*, in note 4, p. 6.

12. I argue elsewhere that Foucault's poststructuralist analysis of power is actually incoherent without a conception of social agency. See Karen Litfin, *Ozone Discourses: Science and Politics in Global Environmental Cooperation* (New York, NY: Columbia University Press, 1994), pp. 22-23.

13. For an overview of the structurationist approach which informs this article, see Alexander Wendt, 'The Agent-Structure Problem in International Relations Theory', *International Organization* (Vol. 41, No. 3, 1987), pp. 335-70.

14. While knowledge brokers may be the agents of a discursive shift, what is fundamentally important is not their identities, but rather their ability to translate and interpret knowledge in accordance with new or pre-existing sets of linguistic practices which entail specific constructions of the world.

decision-makers.[15] Their influence derives from the plausibility of their interpretations, the loudness of their voices, and the political context in which they act. While they typically operate at low or middle levels of governments and international organisations, they are also found at higher levels, as in the US President's Council of Economic Advisors and the Science Advisor. They may also come from the ranks of nongovernmental organisations (NGOs), which aim their interpretations not just at policy-makers, but at the public through the mass media. The ability of knowledge brokers to frame and interpret information is a substantial source of power, especially under conditions of scientific uncertainty such as those which characterise environmental problems.[16] Essentially, knowledge brokers serve as channels for discourse and as intermediaries between information and decision-makers, often clothing bare facts with social meaning.

The Montreal Protocol on Substances that Deplete the Ozone Layer,[17] and its subsequent amendments, provide an excellent case for a discursive approach, because of the pivotal role of science. In general, environmental problems are not simply physical events; they are *discursive phenomena* that can be studied as struggles among contested knowledge claims, which become incorporated into divergent narratives about risk and responsibility. The struggle that ensues is a struggle for meaning in which no meanings are ontologically fixed.[18] Precisely because the ozone regime looks like an example of epistemic cooperation, or consensual knowledge generating policy agreement, it provides an excellent vehicle for the study of alternative approaches. Furthermore, because the regime is upheld as a prototype for future agreements, understanding its evolution is important for drawing inferences about policy-making under conditions of scientific uncertainty and global ecological interdependence.

Superficially, the landmark treaties appear to have been the result of a rigorous process of risk analysis, with sophisticated atmospheric models providing the scientific basis of the negotiations. This is the thesis of Ambassador Richard Benedick, US chief negotiator for the Montreal Protocol and author of a widely read version of the ozone story.[19] It would be a mistake, however, to conclude

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15. See James Sundquist, 'Research Brokerage: The Weak Link', in Laurence Lynn (ed). *Knowledge and Policy: The Uncertain Connection* (Washington, DC: National Academy of Sciences, 1978), pp. 126-144.

16. On the importance of framing and interpretation in decision-making, see Paul Slovic, Baruch Fischhoff, and Sarah Lichtenstein, 'Facts versus Fears: Understanding Perceived Risk', in Daniel Kahneman, Paul Slovic, and Amos Tversky (eds.), *Judgement under Uncertainty: Heuristics and Biases* (Cambridge: Cambridge University Press, 1985), pp. 463-89, and Amos Tversky and Daniel Kahneman, 'The Framing of Decisions and the Psychology of Choice', *Science* (Vol. 211, No. 5, 1981), pp. 453-58.

17. Montreal Protocol on Substances that Deplete the Ozone Layer, September 1987 (Nairobi: UNEP, 1985).

18. Charles J. Fox and Hugh T. Miller, *Postmodern Public Administration: Toward Discourse* (Beverly Hills, CA: Sage, 1995), pp. 10-11. Fox and Miller use Habermas' theory of ideal speech acts to distinguish between authentic and monologic discourse. This article assumes no such normative framework.

19. Richard E. Benedick, *Ozone Diplomacy: New Directions in Safeguarding the Planet* (Cambridge, MA: Harvard University Press, 1991).

that science provided a body of objective and value-free facts from which international cooperation emerged, as the epistemic cooperation hypothesis would suggest. Rather, knowledge was 'brokered', so that questions of value were rendered as questions of fact, with exogenous factors shaping the credibility of alternative discursive strategies: in the Montreal Protocol process, science was *framed* by knowledge brokers. While Haas' reading of the ozone regime as the work of an epistemic community highlights the role of knowledge in shaping interests,[20] his inattentiveness to discourse causes him to neglect the role of values and interests in shaping knowledge claims. Consequently, he overestimates the role of scientists—information producers—and underestimates the role of knowledge brokers—information framers. Similarly, he fails to grasp the significance of contextual factors like the Antarctic ozone hole, which was crucial to the eventual outcome of the negotiation process.

The Montreal Protocol process is essentially the story of how a *status quo* discourse favouring inaction was supplanted by a precautionary discourse. The precautionary principle, an emerging principle of international environmental law, holds that, in the face of scientific uncertainty, regulators should act to prevent harm rather than wait until damage occurs.[21] This premise, which expresses a *philosophical* rather than a *scientific* judgement, entails radically different discursive strategies from those which underlie the premise that chemicals are innocent until proven guilty. Precautionary discourse, as I use it, refers to a set of linguistic practices informed by this principle and embedded in a social network (in this case, a group of knowledge brokers); precautionary action applies this principle to specific policies.

Scientific Discourse Prior to the Negotiations

In 1985, twenty nations, including all of the major chlorofluorocarbon (CFC) producers, signed the Vienna Convention for the Protection of the Ozone Layer,[22] which called for information-sharing on ozone-related science and technology. While that treaty failed to mandate precautionary action to control potential ozone-depleting chemicals, it did establish the basis for a discursive shift by obligating states to refrain from activities *likely* to modify the ozone layer. Equally importantly, it established an international network of diplomats, scientists, and officials who were conversant in ozone science and accustomed to working together.[23]

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20. Peter Haas, *op. cit.*, in note 5.
21. Daniel Bodansky, 'Scientific Uncertainty and the Precautionary Principle', *Environment* (Vol. 33, No. 7, 1991), pp. 4-5.
22. Vienna Convention for the Protection of the Ozone Layer, March 1985 (Nairobi: UNEP, 1985).
23. During the treaty revision process, that group, which traced its lineage to the Vienna Convention negotiations, was sufficiently cohesive to be called 'the ozone club' (interview with Eileen Claussen, Chair of the US delegation to the Second Meeting of the Parties in 1990, 7 September 1992).

One year later, the first comprehensive international report on atmospheric ozone was published by the World Meteorological Organization and the US National Aeronautics and Space Administration (hereafter *WMO/NASA*).[24] Robert Watson, a NASA scientist who also served as a knowledge broker, coordinated the assessment, which served as the primary scientific basis for the Montreal Protocol negotiations. *WMO/NASA* studied the earth system holistically, stressing complex climatic issues over simple ozone depletion. However, the section on predicted ozone changes received by far the most attention because of its more workable policy implications. On the basis of the continued release of CFCs and halons at 1980 levels, computer models predicted modest global ozone losses of 5-9 per cent, by the end of the next century. These predictions were strongly linked to emission trends for the greenhouse gases, which constituted the greatest source of uncertainty. Ground-based observations indicated no change in global ozone levels, though measured losses in the upper stratosphere were consistent with the modelled predictions. Indeed, some satellite measurements of global ozone loss, considered unreliable at the time, provided the impetus for a comprehensive study of global ozone levels, released in 1988, which would come to influence the post-Montreal treaty revision process. Despite these uncertainties, especially with respect to greenhouse gases, the general tone of the report was one of confidence. One has the sense that ozone science had reached a plateau where no major controversies were expected, with perhaps the only indication to the contrary being a brief reference to 'a considerable decrease in Antarctic total ozone during the spring period...which is presently the subject of further analysis'.[25]

From a political perspective, the most interesting thing about *WMO/NASA* is that it offered something for everybody. Those who supported the *status quo* could argue that the predictions were not dire and would not occur for a long time. No total ozone losses had been confirmed, and ozone loss would be tempered by rising levels of greenhouse gases. On the other hand, those who embraced a precautionary discourse pointed out that, consistent with the models, upper stratospheric ozone was already being lost. They cited the potential folly inherent in relying on increased levels of greenhouse gases to mitigate the impact of CFCs. Whatever their discursive proclivities, all the participants in the Montreal Protocol process accepted *WMO/NASA* as the factual basis for the ensuing treaty negotiations. However, science did not provide the objective facts from which policy conclusions could be drawn. Rather, *WMO/NASA*'s scientific report was incorporated into pre-existing discourses about risk and responsibility.

The political reception of *WMO/NASA* provides a good example of the social construction of scientific discourse and the inter-relatedness of knowledge and

24. *Atmospheric Ozone* (Washington, DC: World Meteorological Organization and US National Aeronautics and Space Administration, 1985). I have detailed the social construction of science as represented in *WMO/NASA* with respect to the ozone hole, in Litfin, *op. cit.*, in note 12, pp. 82-86 and 97-99.
25. *WMO/NASA*, *op. cit.*, in note 24, p. 20.

interests. First, the very purpose of the assessment was to transcend nationalistic biases. Watson and other scientists 'wanted to break down the false scepticism that was based on things like "This is only American Research"'.[26] Second, *WMO/NASA*'s findings allowed contending factions to interpret the report's conclusions in ways that bolstered pre-existing policy discourses, despite the fact that the science was more refined than at any previous time. Third, atmospheric science was fundamentally tied to economic projections, and these were intertwined with the interests and values of knowledge brokers: industry wanted low projections, while environmentalists wanted high projections.

Advocates of precautionary action raised a volatile issue implicit in *WMO/NASA*. The scientists, for all their sophisticated modelling, relied on economic projections of CFC growth rates and had arbitrarily chosen 1980 as a baseline date. A group of knowledge brokers at the US Environmental Protection Agency (EPA), intent upon interpreting *WMO/NASA* in light of the precautionary discourse, saw that this was misleading for three reasons: there was a global recession in 1980, that date did not take into account the potential for mushrooming CFC use in developing countries, and the figures ignored the burgeoning demand for CFC-113 in the electronics industry. Since predicted ozone losses varied greatly with CFC emissions, these knowledge brokers, who had advocated precautionary action even prior to Vienna, took on the task of demonstrating the inadequacy of the 1980 baseline date.[27]

After the Vienna Convention was signed, the UN Environment Programme (UNEP) and the EPA held a series of informational workshops, as a prelude to formal negotiations on a regulatory protocol. Given the discord at the first economic workshop, held in Rome during May 1986, it is remarkable that the Montreal Protocol was negotiated in just over a year. There was not even agreement on figures for *current* production, use, trade, and emissions of CFCs, much less on *future* trends. Accepted knowledge reflected the perceived interests of the principal adversaries: the United States and the European Community (EC). The United States, threatened with domestic regulation beyond its 1978 aerosol ban as a result of a lawsuit by the Natural Resources Defense Council (NRDC), desired a treaty that would make a 'level playing field'. The EC, with its CFC industry operating at only 65 per cent capacity, and facing no threat of regulation at home, opposed strict controls and favoured a cap on production capacity. There was a range of views within the EC, with the British and French emphasising the uncertainties, and the Dutch coming closest to the American position. Japan, dependent on CFCs for its microelectronics industry, and China,

26. Interview with Robert Watson, 13 December 1992.
27. Among the knowledge brokers associated with the EPA were John Hoffman, Stephen Seidel, James Losey, Michael Gibbs, and James Hammitt. See UNEP/WG.151/Background 2, Paper 1, and James Hammitt *et al., Product Uses and Market Trends for Potential Ozone-Depleting Substances, 1985-2000* (Santa Monica, CA: Rand Corporation, 1986).

with plans massively to expand its refrigeration industry, predictably sided with the British and the French.

Next, the UNEP and the EPA held an international conference on the health and environmental effects of ozone depletion and climate change. This gathering, unlike the economic workshops which were laying the groundwork for the upcoming political negotiations, was an exclusively scientific meeting. Although no new science was presented, the meeting was significant because of the extent to which climate change dominated the agenda. According to EPA Administrator Lee Thomas,

> [s]cience tells us that ozone depletion and global warming are inexorably interconnected. However, the domestic and international politics surrounding each issue are separate and unique. Combining the two in one conference had the potential to confuse and compound the political controversy ounding ssue. Separating the issues would fail to address their physical inter-dependence. In the end the choice was clear: we resolved this issue by recognizing that this conference is first and foremost a scientific meeting, not a political one, and therefore it should be organized around the science.[28]

For many at the UNEP and the EPA, the ozone issue was nested within the larger issue of climate change. A treaty on the former could serve as a springboard for dealing with the latter. However, ozone depletion was perceived to be politically manageable, whereas climate change was not. Although the issues were scientifically inextricable, a consensus reigned among policy-makers and knowledge brokers that they would be decoupled in a policy context. Passing mention was made of the fact that CFCs were greenhouse gases, so that limiting them would ease global warming, but otherwise, the policy discourse on ozone depletion was severed from its scientific links to climate change.

The second workshop, held in Leesburg,[29] was dominated by the EPA, both in terms of numerical representation and discursive competence. The EPA papers were well-crafted interpretations of atmospheric science, designed to heighten the sense of urgency and thereby promote precautionary action. The papers shared one underlying objective: *to shift the policy discourse by extending the relevant time frame well into the next century.* The papers by John Hoffman, Chairman of the EPA's Stratospheric Protection Task Force and a key knowledge broker in the ozone negotiations, are especially noteworthy for their emphasis on the

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28. Lee Thomas, 'Global Environmental Change: The EPA Perspective', in James Titus (ed.), *Effects of Changes in Stratospheric Ozone and Global Climate* (Washington, DC: US Environmental Protection Agency, 1986), p. 27.
29. See, 'Report of the Second Part of the Workshop on the Control of Chlorofluorocarbons, Leesburg, 8-12 September 1986', UNEP/WG/151/Background 2.

long atmospheric lifetimes of CFCs.[30] His primary contribution to the discourse of precautionary action was his 'chlorine-loading' analysis: *in order simply to stabilise chlorine concentrations at 1986 levels, the presence of past emissions in the atmosphere required an immediate 85 per cent cutback in CFC emissions.*[31] The EPA knowledge brokers never rebutted the EC position on *political* grounds, although the EC viewpoint was patently unfair to US industry. Nor did the EPA promote any particular policy position.[32] Rather, they *scientifically* demonstrated the inadequacy of weak proposals by spelling out their long-term implications. The EC, on the other hand, buttressed its position with little scientific analysis. Largely as a result of the EPA's discursive strategies, a general consensus emerged in Leesburg that CFCs should be regulated, although the degree and timing of controls were still far from clear.

Two factors in particular had considerable significance in shaping the EPA's discursive strategy. First, the discovery of the Antarctic ozone 'hole'[33] crucially enhanced the credibility of Hoffman's proposal. Second, the discursive proclivities of the EPA were in large part determined by key EPA knowledge brokers' general social orientation towards risk and responsibility.

The Impact of the Discovery of the Antarctic Ozone Hole

In May of 1985, two months after the Vienna Convention was signed, and just prior to publication of *WMO/NASA*, a paper was published that would transform both scientific and political perceptions of the problem.[34] Joseph Farman, leader of the British Antarctic Survey, reported major losses of stratospheric ozone for three consecutive years since October 1982. Though Farman did not seek to explain the hole, he stated that 'chemical causes must be considered' and included a graph showing a strong correlation between CFC concentrations, which his group had also measured, and ozone losses.[35]

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30. John Hoffman, 'The Impact of Control Strategy Alternatives in Meeting Future Demands for Chlorofluorocarbons', and his 'Analysis of Stringency of Control Strategies to Achieve Alternative Ozone Depletion Limits'.
31. UNEP/WG.148/3, Annex I, p. 5.
32. The US position was not finalised until November 1986. A proposal tabled by environmental activists at Leesburg called for a full phase-out of CFC's over ten years (see UNEP/WG.148/3, Paper 6). That proposal is remarkably similar to the position eventually adopted, but EPA officials involved in formulating the US position deny being influenced by it.
33. Because the depletion was never total, the term 'ozone hole' is technically a misnomer. Some industry representatives saw the rhetorical advantages inherent in the term and objected to it, preferring to speak of 'temporary ozone losses'. It has been suggested that names that include repeated sounds, like the three 'o's in 'ozone hole', may have 'an advantage in the marketplace of ideas', See Editorial, *Los Angeles Times*, 28 November 1986.
34. J.C. Farman, B. G. Gardiner and J.D. Shanklin, 'Large Losses of Total Ozone in Antarctica Reveal Seasonal ClO_x/NO_x Interaction' *Nature*, (Vol. 315, No. 6016, 1985), pp. 207-10.
35. *Ibid.*, p. 210.

NASA's Robert Watson suggested that the 'Antarctic ozone phenomenon' should not be allowed to influence the terms of the protocol. He argued that scientists should first complete an intensive one-to-two year investigation, after which regulatory policies could be re-examined.[36] Watson's counsel was later adopted as an explicit premise of the international negotiations: the ozone hole was officially ignored. Because of this decision, it is difficult to ascertain its role in the negotiations. Nonetheless, the hole significantly altered the bargaining context, thereby lending credibility to certain modes of framing the available knowledge. The ozone hole, signalling a dangerously high probability of ecological disaster, precipitated a *sense of crisis* conducive to the precautionary discourse eventually sanctioned in Montreal. Scientific uncertainty continued to serve as a justification for caution, but the meaning of 'caution' shifted dramatically: suddenly environmental vulnerability appeared to be more acute than industrial vulnerability.

Once the hole's existence was confirmed by NASA satellite data, the race was on to explain it. Three major sets of hypotheses sprang up, only one of which involved CFCs.[37] That hypothesis, which was later confirmed, suggested that the icy stratospheric clouds unique to the Antarctic winter could sequester a large amount of chlorine from CFCs, and release it in the spring melt. However, even that hypothesis did not necessitate a precautionary approach because the hole did not have to be *interpreted* as having any implications beyond Antarctica. The other two explanations involved atmospheric dynamics and the eleven-year solar cycle. Amid the debates, Watson organised the first National Ozone Expedition (NOZE I), in the austral spring of 1986. While the expedition refuted the solar cycle hypothesis and hinted that CFCs might be the culprit, only a second expedition, one that included aircraft-based measurements, could dispel the uncertainties.[38] The data from the airborne expedition, definitively linking the hole to CFCs, were not available until after the Montreal Protocol was signed.

With the hole unexplained, its implications for the credibility of particular discursive practices were open to interpretation. In the social construction of the Antarctic phenomenon, one fact stood out in stark relief for both scientists and policy-makers: *the hole was not predicted by any atmospheric models, including WMO/NASA*. Among scientists, this induced a heightened sense of humility and a frantic investigative effort. In policy circles, it was translated into a signal supporting precautionary action. Most importantly, the hole undercut the credibility of the atmospheric models and opened the door to *an alternative way of framing the scientific knowledge*, which had far more radical policy implications. The models predicted only modest ozone depletion with constant 1980

36. UNEP/WG.148/3, p. 15.
37. On the CFC-related hypothesis, see Susan Solomon, *et al.*, 'On the Depletion of Antarctic Ozone', *Nature* (Vol. 321, No. 6072, 1986), pp. 755-58. All three explanations were explored in a special issue of *Journal of Geophysical Research* (Vol. 91, No. 11, 1986), devoted to the Antarctic ozone hole.
38. 'Chemical Process Seen in Ozone Hole', *New York Times* (21 October 1986), p. C-3.

CFC emissions, but the models were wrong. There was another way of framing the issue, which did not rely on any models: Hoffman's calculation supporting an 85 per cent reduction in CFC emissions required no models, only knowledge of production data and atmospheric lifetimes. As one modeller put it, '[t]he truth will be between the chlorine-loading perspective and the modeled calculations, but the hole gave credence to the chlorine-loading scheme'.[39] Hoffman's mode of framing the science gained much of its salience from the discovery of the Antarctic ozone hole.

The decision to shift the debate from ozone depletion to chlorine concentrations was a strategic one. According to EPA contractor Michael Gibbs,

> [t]here was no new information here, just a different way of framing it. We thought: since the hole may be linked to concentrations, let's shift the debate. *This also shifts the focus to the warming issue, and in general to the responsibility to the future.* It would not have worked one year before; *it only worked because of the Antarctic hole.*[40]

This mode of framing the science therefore had an explicit political purpose: to promote the precautionary discourse, not just for ozone but for the climate issue as well. As Hoffman's simple calculation gained publicity, '85 per cent became the line in the sand for environmentalists'.[41]

Would the Montreal Protocol have been negotiated without the Antarctic ozone hole? All of the individuals I interviewed concur: yes, but the resulting treaty would have been far weaker and would have had fewer signatories. They recall the extensive media coverage of the hole which permeated the political *milieu* of the negotiations, particularly a powerful time-lapse colour videotape assembled by NASA from satellite data, and broadcast internationally. Tellingly, advocates of the *status quo* discourse thought it extremely important 'not to let all the publicity about [the ozone hole] get dragged into the debates'.[42] Although the negotiators agreed to disregard the hole, the extensive press coverage that it received made it difficult to ignore. Because of the uncertainty regarding the causes of the hole, it dramatically altered both the context of the negotiations and the acceptability of various modes of framing the science. Its discovery, suggesting that the consequences of under-reacting might be worse than the consequences of overreacting, promoted the discourse of precautionary action.

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39. Interview with Guy Brasseur, Belgian atmospheric modeller, 5 November 1990.
40. Interview with Michael Gibbs, statistical policy analyst for ICF, an EPA contractor, 22 November 1989, emphasis added.
41. Committee on Environment and Public Works, US Senate Hearing, *Ozone Depletion, the Greenhouse Effect, and Climate Change*, (Washington DC: US Government Printing Office, 28 January 1987), p. 61. The quote is from an interview with James Losey, senior staff officer for the EPA's International Activities Office, 17 September 1990.
42. Interview with David Gibbons, Deputy Assistant Secretary for Environment and Resources, Office of Management and Budget. Gibbons chaired the US interagency meetings.

Scientific *ignorance*, rather than scientific *knowledge*, set the stage for international cooperation.

The Discursive Orientation of EPA Knowledge Brokers and the Evolution of the US Position

During the summer of 1986, the EPA and the State Department contacted other US agencies to develop a bargaining position. Encountering little interest, the State Department sent a draft paper to its embassies around the world to get feedback from foreign governments. That paper called for a scheduled phase-out, which later became a 95 per cent cutback of CFCs and halons by the year 2000.[43] Such a strong regulatory proposal, emanating from the conservative Reagan administration, was anomalous. The US position, reducible neither to economic and political interests nor to pure science, grew out of discursive manoeuvring around political and scientific considerations. Although Du Pont, a US-based company and the world's largest CFC producer, was likely to be first to market CFC substitutes, no segment of US industry supported the US position. Further, although the EPA was under some pressure to control CFCs because of the pending NRDC lawsuit, the lawsuit was a minor consideration and the proposed phase-out far exceeded the NRDC's hopes. More important than interest group pressure was the *precautionary orientation* at the EPA and the State Department.

From the beginning of his tenure as EPA Administrator in 1985, Lee Thomas took a considerable interest in the ozone issue.[44] He personally announced the EPA's new perspective on ozone at a workshop in March 1986:

> [i]n the face of all this scientific uncertainty, one might ask why...not simply adopt a 'wait-and-see' attitude until depletion is actually confirmed? Let me address this question squarely. EPA does not accept, as a precondition for decision, empirical verification that ozone depletion is occurring.... *[We] may need to act in the near term to avoid letting today's 'risk' become tomorrow's 'crisis'*.[45]

Rather than the science itself, it was Thomas' *discursive orientation* that drove his decision: his understanding of the problem was rooted in a particular narrative about risk and responsibility in the social world. As Thomas recalls,

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43. Department of State, 'Principles for an International Protocol on Stratospheric Ozone Protection' (Washington DC: US Government Printing Office, 3 November 1986).
44. Thomas' position cannot be explained by a bureaucratic politics approach. Neither of his predecessors supported strict controls on CFC's, and one of them, Anne Gorsuch Burford, described the ozone problem as 'a non-issue'. See US Senate Hearing, Committee on Environment and Public Works, 'Nominations of Anne M. Gorsuch and John W. Hernandez, Jr.' (1 May 1981).
45. Thomas, *op. cit.*, in note 28, p. 27, emphasis added.

referring to his disagreement with William Graham, President Reagan's Science Advisor and a staunch opponent of regulation,

> Graham looked at it from a purely scientific perspective, whereas I looked at it from more of a policy perspective. Where there was uncertainty, he thought we needed more research and I thought we needed to be cautious. We just looked at the same science and came to two different conclusions.[46]

Because he neglects the discursive nature of knowledge brokerage, Haas misconstrues the atmospheric scientists as the principal architects of the US position.[47] In actuality, very few scientists offered any policy recommendations. Watson, for instance, believed that 'the science didn't justify a 95 per cent cut', expressing concern that the rush could promote unsafe alternatives.[48] Daniel Albritton, the other major US scientist advising policy-makers, continued to harbour doubts about the CFC-ozone link.[49] Rather, it was the EPA's knowledge brokers, with later support from the UNEP and other national environmental agencies, who framed the science in light of the precautionary discourse.

Industry representatives were disgruntled with the negotiating position formulated by the EPA and the State Department, and they contacted several cabinet-level departments. Subsequently, a series of interagency meetings was convened, in order to educate political appointees and senior career officers on the technical aspects of the ozone problem. The fractious meetings, which pitted the precautionary discourse against the *status quo* discourse, paralleled the international bargaining, and spilled over into the press. Throughout the debates, the risk had been framed in terms of increased skin cancer rates due to ozone depletion. However, this narrow mode of framing the issue ultimately subverted the policy position of those who adopted it. In the course of the debates, it became clear that widening the scope of risk gave credibility to the precautionary discourse. In her presentations at the interagency meetings, cancer specialist Margaret Kripke emphasised that, although skin cancer received ample US media attention, it was a mistake both scientifically and politically to focus on it. The most serious issues, she argued, were the impact of increased ultraviolet radiation on the human immune system, the world's food supplies, and aquatic ecosystems.

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46. Interview with Thomas, 20 November 1989.
47. Haas, *op. cit.*, in note 4, p. 23.
48. These views were expressed in a personal interview with Thomas and in Congressional testimony. See US Senate Hearing, Committee on Energy and Commerce, *Ozone Layer Depletion* (Washington DC: US Government Printing Office, 9 March 1987), p. 90.
49. Interviews with Ralph Cicerone and Richard Stolarski, atmospheric scientists, 10 September 1990 and 11 December 1989, respectively.

She also believed that since skin cancer primarily affects caucasians, global cooperation would depend on framing the issue differently.[50]

The turning point in the interagency wrangling came when the Interior Secretary, Donald Hodel, urged the administration to consider a policy of 'personal protection', instead of precautionary action. He apparently asserted that a public relations campaign could promote the use of sunglasses and sunscreen, without violating the administration's anti-regulatory philosophy.[51] The public outcry was swift and intense. A *New York Times* editorial lamented that Hodel's 'meddling' threatened the negotiations, and 'forced the United States from a widely admired position of leadership into humiliating retreat'.[52] Environmentalists, wearing hats and sunglasses at a press conference the next day, called for Hodel's resignation. Their statement that 'fish don't wear sunglasses' was cited throughout the press accounts, highlighting the political folly inherent in framing the issue narrowly in terms of skin cancer.[53] Hodel's *faux pas* undercut the *status quo* discourse and, ultimately, the original US position in support of a 95 per cent phase-out was sustained.

As with the Antarctic ozone hole, the discursive framing of science had important policy implications. Those who defined the issue solely in terms of skin cancer were discredited when they publicised their views, even though most research on the effects of ozone depletion had focused on skin cancer. Beyond the domestic consensus in favour of a global treaty, the nature of the US national interest was not initially obvious. Rather, it was socially constructed through a process of internal debate that blended both science and politics.

Negotiating the Montreal Protocol

During the negotiations, from December 1986 to September 1987, the two principal adversaries were the EC (backed by Japan, the Soviet Union and China) and the United States (backed by Canada, the Nordic countries, and New Zealand). Within the EC, there was a diversity of opinion: West Germany, the Netherlands, Denmark, and Belgium favoured stricter controls, but only Germany was a major producer. The French and British distrusted the Americans' motives, wrongly suspecting that a drastic regulatory proposal coming out of the Reagan administration could only mean that US industry had secretly developed CFC

50. Interviews with David Gibbons and Margaret Kripke, chair of the subcommittee of the EPA's Scientific Advisory Board which reviewed the 1987 ozone risk assessment, 6 December 1989 and 3 October 1990, respectively. See Margaret Kripke, 'Sun and Ultraviolet Ray Exposure', *Cancer Prevention* (Vol. 1, No. 1, 1990), pp. 1-7.
51. 'Administration Ozone Policy May Favor Sunglasses, Hats', *Washington Post* (29 May 1987), p. A-1.
52. 'Through Rose-Colored Sunglasses', *New York Times* (31 May 1987), p. E-28.
53. *Ibid.*; 'Hodel Proposal Irks Environmentalists', *Los Angeles Times* (30 May 1987), p. I-2; and 'Alternative to Ozone Pact Hit', *Washington Post* (30 May 1987), p. A-5.

substitutes.[54] A third group, which included the countries closest to Antarctica, was initially neutral, but later gravitated towards the US position.

At the first session, there was overall support for some limits on CFCs, dating from the Leesburg workshops, although the EC refused to discuss anything beyond a freeze. Both the EC and the United States defended their positions in terms of economic 'knowledge', arguing that their proposals would 'exploit the law of supply and demand' by raising the prices of CFCs, and forcing producers to find safe substitutes.[55] The United States argued that neither a freeze nor a production cap would achieve this goal quickly enough, and that the social costs would be much higher if drastic reductions were required in the future. Of course, the Antarctic ozone hole, which had not yet been scientifically explained, and which could not be discussed, provided the strongest evidence that future reductions might be necessary. The long atmospheric lifetimes of CFCs, the United States argued, meant that delaying reductions would allow unacceptable levels of chlorine to accumulate. Thus, the debate between the United States and the EC was really about *the appropriate time frame to employ in formulating a regulatory policy.*

When the delegates reconvened in February 1987, Ambassador Benedick, chief negotiator for the United States, depicted himself as a victim of domestic pressure. He informed his colleagues of a pending Congressional bill that would ban imports made with CFCs. More interesting for a discursive approach, however, is his use of science to legitimate his position. To support his precautionary stance, Benedick used the chlorine-loading argument: only an immediate 85 per cent reduction in CFCs could stabilise chlorine levels. However, stepping beyond the precautionary discourse, he declared that 'both satellite and land-based measurements suggest that the process of ozone destruction may already be underway'.[56] His reference can only be to the Antarctic ozone hole, which the group had decided to ignore, or to measurements deemed highly unreliable in *WMO/NASA*. Benedick's allusion to measured ozone loss contradicts his later assertion that the Montreal Protocol was a *preventive* action, 'based at the time not on measurable evidence of ozone depletion or increased radiation but rather on scientific hypotheses'.[57] In discursive politics, partial truths and selective framing lend persuasive power to one's position. In

54. Interviews with Guy Brasseur and Kevin Faye, Executive Director of the Alliance for a Responsible CFC Policy, lobbyists for the US CFC industry, 5 November 1990 and 4 December 1989, respectively. The simplest argument against the supposition that the US position was rooted in economic interests is that its own CFC industry argued vehemently against the US proposal.

55. UNEP/WG.151/L.4. See also, 'Hard Choices Await Industry as Ozone-Layer Fears Rise', *Wall Street Journal* (2 December 1986), p. 4.

56. Richard Benedick, 'International Efforts to Protect the Stratospheric Ozone Layer', *Department of State Current Policy* (No. 931, 1987), p. 1.

57. Benedick, *op. cit.*, in note 19, p. 43.

hindsight, Benedick portrays himself as a visionary architect of precautionary action; in the heat of battle, he insinuates that a disaster is already occurring.

During the first two rounds of talks, advocates of a strong protocol grew increasingly frustrated as their adversaries used scientific uncertainties to legitimate incremental action. Consequently, the US delegates sought to export the precautionary discourse through informal conversations, bilateral meetings, and satellite conferences. EPA staff contacted their counterparts in foreign environmental agencies, and US diplomats met with journalists, officials and scientists from dozens of countries, urging precautionary action. These bilateral communications facilitated consensus in Europe, Japan, and some developing countries.

The final agreement, while falling short of the US position, required scheduled reductions of domestic CFC and halon consumption by up to 50 per cent by the year 2000. Cuts in production could lag by 10 per cent, to supply importing countries and to allow EC countries to rationalise production, while developing countries could delay implementation of the phase-down schedule for ten years. Trade provisions were included as an incentive for all countries to join the agreement. Periodic scientific reviews, which led to two sets of treaty revisions within five years, were mandated at least every four years. The treaty was upheld as an 'unprecedented' instance of precautionary action on a global scale. Mostafa Tolba, Executive Director of the UNEP, called it 'the first truly global treaty that offers protection to every single human being on this planet, ...unique because it seeks to anticipate and manage a world problem before it becomes an irreversible crisis'.[58]

From Precautionary Discourse to Crisis Management

The revision process of the Montreal Protocol embraced a number of issues, three of which are explored in this section, and which demonstrate how policy is shaped by discursive practices. First, and most importantly, international policy on CFC production and use was more coordinated, and became more restrictive. This was not simply the result of widespread epistemic cooperation. Rather, it was the consequence of a deepening sense of crisis, and of the continuing salience of the chlorine-loading mode of framing the science. Second, policy on substitute technology was, for some time, favourable to the use of hydrochlorofluorocarbons (HCFCs). In part, this was a result of discursive manoeuvring by large chemical-producing companies, who employed a specific mode of framing the science to support their arguments. Finally, a new, emerging threat concerns methyl bromide (MB). Here again, international policy will be decisively shaped by discursive practices.

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58. UNEP Press Statement, 22 September 1987.

Post-Montreal CFC Policy: Precautionary Discourse and Environmental Bandwagoning

No sooner was the treaty signed, than a scientific consensus emergedon three core issues: the Antarctic ozone hole, global depletion, and a significant risk of depletion over the Arctic. Within weeks of Montreal, the Antarctic Airborne Expedition announced that the hole was indeed caused by CFCs. In March 1988, NASA's Ozone Trends Panel confirmed this conclusion. The panel cited the potential for large losses over the Arctic and revealed that ozone was being depleted globally.[59]

Haas' characterisation of the post-Montreal period in terms of 'environmental bandwagoning', suggests the globalisation of his epistemic community.[60] This is, however, a superficial reading of the story. Policy coordination did not emerge automatically from scientific consensus, but only in conjunction with specific discursive strategies. The treaty revisions adopted at London in 1990 and at Copenhagen in 1992 (summarised in Table 1) were not a simple matter of consensual knowledge begetting international cooperation. Nor did science, once a consensus had emerged, drop out of the picture, leaving the outcomes to be determined by traditional threat-and-bribe politics. With the new findings, precautionary action was no longer an option because ozone depletion was clearly a current crisis, rather than a potential disaster. From 1988 onwards, a constant barrage of news about ozone losses reinforced this perception.[61]

A week after NASA's announcement, Du Pont declared that it would soon halt its CFC production. While the company claims that its decision was entirely science-driven, certain practical concerns of long-term profitability and corporate reputation would have been hard to ignore. Du Pont's decision was met with cynicism both by environmentalist groups and by European industry, which dubbed the ozone treaty 'The Du Pont Protocol'. Clearly, the Montreal Protocol represented a golden marketing opportunity for the first company to devise CFC substitutes. With some research already under its belt after the US aerosol ban in 1978, Du Pont was well-positioned to seize that opportunity. However, as I argue below, ensuring that HCFCs, rather than other technologies, dominated the substitutes market would require serious discursive manoeuvring on the part of Du Pont and other chemical giants.[62]

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59. NASA, 'Executive Summary of the Ozone Trends Panel', Washington, DC, 15 March 1988.
60. Haas, *op. cit.*, in note 5, pp. 213-14.
61. For some of the US press coverage on ozone depletion between 1987 and 1992, see: 'Ozone Depletion Worsens: Hazard to Researchers Seen', *Washington Post* (28 October 1987), p. A-9; 'New Ozone Threat: Scientists Fear Layer is Eroding at North Pole', *New York Times* (11 October 1988), p. C-1; and 'Summertime Harm to Ozone Detected over Broader Area', *New York Times* (23 October 1991), p. A-1.
62. On Du Pont's decision, see Forest Reinhardt, 'Du Pont FREON Products Division: Prepared as a Harvard Business School Case' (Washington, D.C.: National Wildlife Federation, 1989), and Friends of the Earth, *Hold the Applause* (Washington, DC: Friends of the Earth, 1991). I offer my own interpretation of the decision in Litfin, *op. cit.*, in

Britain's conversion was even more remarkable than Du Pont's shift. Prime Minister Margaret Thatcher was deeply distrustful of NASA's role in the Ozone Trends Panel. She commissioned her own report, which corroborated NASA's findings. While her training as a chemist no doubt facilitated her scientific literacy, her change of heart was probably more closely related to her declining popularity. Thatcher was clearly under political pressure, the House of Lords having just passed a resolution calling for 85 per cent reductions in CFCs and halons.[63] Once she embraced that position (which was derived from the chlorine-loading analysis), the stage was set for the EC to follow suit. Within a year of Montreal, the policy positions of the United States and the EC had virtually coalesced around the chlorine-loading approach.

TABLE 1
Montreal Protocol Revisions: Amounts and Dates of Final Reductions for Ozone-Depleting Chemicals

	Montreal (1987)	London (1990)	Copenhagen (1992)
CFCs	50% by 2000*	100% by 2000	100% by 1996
Halons	Freeze by 1992	100% by 2000	100% by 1994
Methyl Chloroform	—	100% by 2005	100% by 1996
Carbon Tetrachloride	—	100% by 2000	100% by 1996
HBFCs	—	—	100% by 1996
HCFCs	—	—	100% by 2030*
Methyl Bromide	—	—	Freeze by 1995

* Apply only to industrialised countries.
The base year used for calculating reductions for each agreement is the year preceding the agreement.

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note 12, pp. 124-27.
63. On Thatcher's policy shift, see 'Tories Plan Green Bill', *The Observer* (2 October 1988), p. 1, and 'Greening of Thatcher Surprises Many Britons', *Washington Post* (4 March 1989), p. A-20.

The predominance of the chlorine-loading mode of framing the science during the treaty revision process corroborates my claim that the Antarctic hole inspired the pre-Montreal shift towards a precautionary discourse. Once the 1988 NASA report confirmed that the computer models were deficient, the chlorine-loading approach became the most credible interpretive strategy for evaluating alternative policy options. If chlorine was the culprit, then the logical solution was to reduce its levels to below the 2 parts per billion (ppb) at which the hole appeared. Thus, John Hoffman, the EPA knowledge broker who authored the chlorine-loading strategy, began working out proposals to revise the treaty the day after he returned from Montreal.[64] He calculated that the Montreal Protocol would permit chlorine levels to mushroom to 11 ppb by the end of the next century, and even with a complete phase-out of CFCs, chlorine levels would still swell to 9 ppb. Lower levels would require eliminating carbon tetrachloride and methyl chloroform, and even then chlorine levels would peak at 4 ppb and only return to 2 ppb after eighty years, assuming full compliance.

After the Antarctic ozone hole was conclusively linked to CFCs, scientists were more willing to serve as knowledge brokers on the basis of the chlorine-loading strategy, and make specific policy recommendations. Two NASA scientists echoed Hoffman's conclusions, adding that the chemical industries' substitute of choice, HCFCs, could only be used transitionally.[65] Their work was the focal point of the UNEP's 1989 *Synthesis Report*,[66] which served as the scientific basis for the 1990 treaty revisions. Figure 1 (see below), drawn from that report, demonstrated the inadequacy of the Montreal Protocol on the basis of chlorine-loading. According to Watson, '[t]he delegates found more useful information in that picture than in the whole report'.[67] As before, the chlorine-loading interpretive strategy was not the only one available. Newly revised ozone depletion potentials (ODPs) indicated that the Montreal Protocol would be sufficient to prevent major ozone losses. However, since the models that generated ODP values had not predicted the Antarctic ozone hole, their predictions were discredited.

Developing countries, which had been relatively silent until this time, raised their voices once it became apparent that CFCs might be banned. The Montreal Protocol had granted them a grace period in which they could increase CFC production, but that would become a moot point with a ban. They argued that they should not have to forego necessities, like refrigeration, in order to solve a problem caused by industrialised countries; nor should they be forced to pay higher prices for substitutes. China and India submitted an innovative proposal, eventually adopted in 1990, for a multilateral fund to finance the transfer of substitute technology to developing countries.

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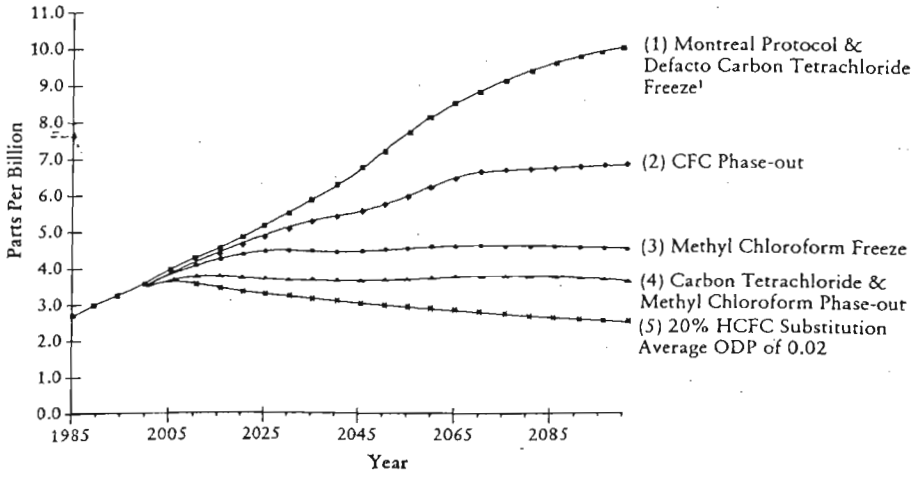
64. Interview with Hoffman, 8 September 1992.
65. Michael J. Prather and Robert Watson, 'Stratospheric Ozone Depletion and Future Levels of Atmospheric Chlorine and Bromine', *Nature* (Vol. 325, No. 6268, 1990), pp. 729-35.
66. 'Synthesis Report', UNEP/OzL.Pro.WG.II(1)4, 13 November 1989.
67. Interview with Watson, 28 August 1992.

FIGURE 1
Atmospheric Chlorine Concentrations with Different Chemical Control Options



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Assumptions: 2000 phaseout of fully halogenated CFCs (except curve 1); HCFCs capture 60% of what the CFC market would have been without regulation (except curve 1), assumed annual average growth rate 1986-2060 (after 2060, use is assumed to be constant); average ODP of substitutes is 0.05 (except curve 5); 100% global participation.
[1] While possibilities exist for an increase in carbon tetrachloride use, such growth is unlikely given the awareness of carbon tetrachloride's potential contribution to stratospheric ozone depletion.

It is worth noting that the developing countries, who were barely represented on the relevant assessment panels, did not frame scientific knowledge on their own behalf. The arguments were there to be made: ozone was being lost near the poles, not over the tropics; the environmental and health effects of ozone depletion were far from clear; and non-Caucasian populations were not prone to skin cancer. Perhaps the developing countries lacked the scientific wherewithal to mount a serious challenge, or perhaps they were persuaded by the new precautionary discourse. In any case, the developing countries eschewed the mantle of scientific legitimacy. Instead, they framed their arguments in terms of sovereignty and equity, and demanded noncommercial access to substitute technology.

International Policy on Substitute Technology

Substitute availability became a key issue during the treaty revision process. Without new technologies, it mattered little what the chlorine-loading

methodology predicted, or whether a technology transfer fund was established. One might argue that the revision process was technology-driven, but this would oversimplify the multi-dimensional relationship between technology and discursive practices. As late as 1987, industry claimed that major CFC reductions were unfeasible, because substitutes were not available.[68] Yet by 1990, CFCs, halons, methyl chloroform, and carbon tetrachloride were all slated for elimination within a decade.

How can we explain this dramatic shift? Was there some spectacular technological breakthrough? As it turns out, the perceived availability of substitutes was primarily a matter of discursive factors, and only secondarily due to advances in engineering. The Montreal Protocol, sounding a potential death knell for CFCs and halons, sparked a major cognitive shift among both producer and user industries, leading to technological innovation.[69] The 1989 Technology Assessment concluded that the five controlled CFCs, plus methyl chloroform and carbon tetrachloride, could be virtually eliminated by the year 2000. In an interesting example of feedback between science and policy, the panel's existence accelerated technological innovation, by nurturing the growth of research networks, industry consortia, and government-industry partnerships. Technological optimism enhanced policy optimism: not only *must* ozone-depleting chemicals be strictly controlled, they *could* be. Ironically, the immediate beneficiaries were the world's largest chemical companies. The elimination of CFCs meant a guaranteed market for substitutes, which favoured the chemical giants with their large research budgets.[70]

The decision to eliminate CFCs sparked a struggle over replacements, which entailed divergent rhetorical strategies among competing groups of knowledge brokers. The CFC producers quickly seized the opportunity to promote two families of compounds: HCFCs, which disintegrate more rapidly in the atmosphere because they contain hydrogen; and HFCs, fluorocarbons which do not impact the ozone layer but which are powerful greenhouse gases. As early as 1989, Du Pont circulated a glossy advertisement promoting these chemicals as supplying 'the balance' between nature and technology.[71] While HCFCs could only be used transitionally because of their contribution to chlorine-loading, the chemical giants argued vociferously that they could be used safely until at least 2030. The basis for their argument was the claim that the Ozone Depletion Potentials (ODPs) for the HCFCs were only 1 to 6 per cent as high as

68. Alliance for a Responsible CFC Policy, *Montreal Protocol: A Briefing Book* (Rosalyn, VA: Alliance for a Responsible CFC Policy, 1987).
69. Interview with Stephen O. Anderson, Director of Technology Transfer and Industry Programs, EPA Global Change Division, 26 August 1992.
70. 'Chemical Giants May Be Winners in Ozone Fight', *Wall Street Journal* (29 June 1990), p. A-5C. Industry, not developing countries, would receive the grants from the technology transfer fund.
71. See Alliance for a Responsible CFC Policy, 'HCFCs and HFCs Provide the Balance' (Rosslyn, VA: Alliance, 1989).

those of the CFCs.[72] In London, that argument was persuasive enough to prevent the parties from imposing any controls on HCFCs. Only in 1992 was a phase-out by the year 2030 adopted for industrialised countries, with no controls adopted for developing countries.

As environmentalists realised, the putative ozone-friendly status of HCFCs is based upon one specific mode of framing the science: the ODPs. However, as these knowledge brokers pointed out, scientists and negotiators had at least temporarily rejected the computer models, and the ODPs they generated, when they adopted the chlorine-loading methodology. If Chlorine-loading Potentials (CLPs) were used instead, then HCFCs appeared to be far more dangerous. For example, the CLP of HCFC-141b calculated over ten years is 0.52, yet its long-term ODP is only 0.08 (CFC-11=1).[73] The tactical shift in environmentalists' rhetoric is worth noting. Until 1990, they emphasised long-term thinking in order to get rid of CFCs; once CFCs were slated for elimination, the rhetoric accentuated short-term thinking in order to minimise the peak chlorine levels that would occur sometime around the year 2000. Thus, neither the short nor the long-term is intrinsically more precautionary.[74]

Why were the parties to the treaty persuaded on the HCFC issue by a rhetorical strategy they had earlier rejected? At least part of the answer lies in traditional power-based and institutional explanations involving the technology transfer fund. At the insistence of the United States, the World Bank, with its long history of supporting capital intensive development strategies that create profits for multinational firms, obtained primary control of the Multilateral Fund. Judging from participants' remarks, a certain discursive inertia on the issue of substitutes may have set in as well. Eliminating the major ozone depleters became the primary task after 1988: how it was done was only a secondary consideration. Thus, the mammoth CFC industry, willingly cooperating in the CFC phase-out and playing a prominent role on the Technology Assessment Panel, had a critical advantage in shaping policy discourse on substitute technology. Discursive strategies, not simply epistemic cooperation, were crucial to the decision regarding *which* chemicals would replace CFCs, and for *how long*.

Precautionary Discourse and Methyl Bromide Policy

In 1992, a major new area of scientific uncertainty emerged. One of the greatest uncertainties of the 1991 science assessment had been the extent to which methyl bromide (MB), the world's most widely used nonpetroleum pesticide, posed a

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72. Programme for Alternative Fluorocarbon Toxicity Testing, 'Alternative Fluorocarbons Environmental Acceptability Study' (Washington, DC: AFEAS/PAFT, 1991).
73. Steve Kretzmann, *Money to Burn: The World Bank, Chemical Companies and Ozone Depletion* (Washington, DC: Greenpeace, 1994), p. 29. Partly because of the high CLPs of the HCFCs, the European Union decided to eliminate HCFCs by 2015, fifteen years ahead of the treaty's schedule for industrialised countries.
74. I am grateful to an anonymous *Millennium* reviewer for clarifying this point.

threat to ozone. The United States favoured a phase-out, because it was under domestic pressure to regulate MB under the Clean Air Act as both an ozone destroyer and an acute toxin. The EC, deferring to its Mediterranean member states, was joined by Israel and some developing countries in opposing regulation. A special assessment was assembled hastily and published in June 1992.[75] As in *WMO/NASA*, there were enough uncertainties to allow the parties to frame the available knowledge according to their perceived interests. In a report given to negotiators at Copenhagen, a broad coalition of NGO knowledge brokers, active on atmospheric toxics and pesticides, adroitly employed science on behalf of the precautionary discourse. As in the HCFC debate, they emphasised MB's *short* atmospheric lifetime, stating: 'Over the next 20 years, every kilogram of MB released into the atmosphere will contribute far more to ozone depletion than a kilogram of a better known ozone destroyer, CFC-11'.[76] Nonetheless, neither the United States nor the NGO coalition was able to persuade the parties to move beyond freezing MB production in 1995.

The treaty revisions adopted at London and Copenhagen were lauded as 'an environmental success story...representing the strongest package of global environmental law ever enacted'.[77] Yet, as Mostafa Tolba adds,

> [t]he question remains: is this enough? We are in the hands of scientists. From them—and we have sought advice from the best in the world—we know that the answer is 'No'. This package is not enough. We have made progress, but we have far to go.[78]

Assuming full compliance, chlorine concentrations are expected to peak at 4.5 ppb shortly after the turn of the century, and only return to pre-Antarctic ozone hole levels of 2 ppb at the end of the next century. The shift to a precautionary discourse was apparently too little, too late.

Thus, even with a strong scientific consensus that major ozone losses were occurring, that they were caused by specific chemicals, and that it was too late for precautionary action, international cooperation was not a straightforward matter. To depict the post-Montreal events as 'environmental bandwagoning' is to paint with too broad a brush: rhetorical strategies were no less important in this phase of the ozone negotiations than they were before. The chlorine-loading approach, which was chosen over other possibilities, was at least as influential in amending the Montreal Protocol as it had been in negotiating it. Furthermore,

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75. UNEP, 'Synthesis Report of the Methyl Bromide Interim Scientific Assessment and Methyl Bromide Interim Technology and Economic Assessment' (Washington, DC: NASA, 1992).
76. Friends of the Earth, *et al.*, *Into the Sunlight: Exposing Methyl Bromide's Threat to the Ozone Layer* (Washington, DC: Friends of the Earth, 1992).
77. UNEP press release, 'From Montreal '87 to Copenhagen '92—An Environmental Success Story' (Nairobi, November 26 1992).
78. *Ibid.*, p. 2.

as the debates on HCFCs and MB show, interpretive strategies continued to play a key role in shaping outcomes.

Conclusion

International decision-making in the face of scientific uncertainty elucidates the mutually constitutive relationship between facts and values, and knowledge and interests. Uncertainty, even within a narrow range, offers a source of scientific legitimation for contending interests, thereby fostering political dissension. On the other hand, as the treaty revision process shows, scientific consensus can facilitate cooperation, even if it does not make it inevitable. Interests were not independent variables either before or after Montreal. Rather, they were a function of accepted knowledge, just as accepted knowledge was strongly conditioned by perceived interests.

Can the ozone treaties be explained solely in terms of material interests? According to Arthur Stein, knowledge only induces cooperation when it enables countries to achieve what they want. For him, issues that revolve around specialized knowledge are 'technical' rather than 'political.'[79] The point here, however, is that the line between technical and political issues is blurred when states' interests must be defined through the discursive framing of scientific knowledge. Certainly, the US had a greater material interest than the EC in promoting a strong regulatory protocol, but the length and intensity of the US interagency debates suggest that interests were redefined on the basis of competing discursive claims. Each shift towards precautionary action, was achieved only after discursive competition. Clearly *beliefs* about material interests were at issue, but these were defined discursively and not in objectively measurable terms.

Furthermore, neither institutionalism nor social choice theory can provide an adequate explanation. While the UNEP provided a crucial negotiating forum, it was not the driving force behind the negotiations. Nor did the Vienna Convention, a different kind of institution, provide the impetus for the ozone treaties, although it no doubt facilitated the process. The choice theoretic claim that the ozone regime came about because there was 'a demand'[80] for it reveals the critical role of political entrepreneurs (knowledge brokers, in this case), but it begs the question of how that demand came about. This question can only be answered with reference to discursive practices.

In problematising interests, the epistemic communities approach moves beyond realist, institutionalist, and choice theoretic approaches. By bringing knowledge into the equation, it opens up new research avenues for exploring power, beyond bureaucratic politics and interest group approaches. Yet, attributing the ozone

79. Arthur A. Stein, *Why Nations Cooperate: Circumstance and Choice in International Relations* (Ithaca, NY: Cornell University Press, 1990).
80. Robert O. Keohane, 'The Demand for International Regimes', in Stephen D. Krasner (ed.), *International Regimes* (Ithaca, NY: Cornell University Press, 1983), pp. 141-71.

regime to an epistemic community is deficient on four counts. First, the epistemic communities approach downplays the framing and interpretation of knowledge. Although a body of consensual scientific knowledge existed, the wide range of plausible interpretations limited its influence. Knowledge brokers were key translators of the available information: scientific *ignorance* was at least as important as scientific *consensus* in determining the terms of the debate. Second, because Haas disregards the discursive nature of knowledge, he wrongly assigns a central role to the atmospheric scientists, who were actually quite reluctant to commit themselves to concrete policy recommendations before the causes of the Antarctic ozone hole were understood. Virtually none of them advocated the 95% phase-out of CFCs promoted by the US delegation. Third, because the epistemic communities literature is agent-centred, downplaying the structural components of the policy process, it tends to disregard contextual factors. Thus, although Haas mentions briefly that 'the negotiations were galvanized'[81] by the discovery of the Antarctic ozone hole, he fails to analyze *how* the hole transformed the context of the negotiations and legitimated a precautionary discourse. Such an analysis requires taking seriously the rhetorical strategies that empower an epistemic community. Fourth, without a discursive reading, the dynamics of the treaty revision period are wrongly characterised in terms of 'environmental bandwagoning'.

Because my analysis places so much emphasis on the Antarctic ozone hole, it is worth considering the counterfactual case of the negotiations occurring in the absence of the hole. Since the negotiators agreed to ignore the hole prior to Montreal, how can we be sure that it had any effect at all? First, US support for a virtual phase-out of CFCs and halons was based upon chlorine concentrations, not on the modeled predictions. Without the hole, there was no reason to adopt the chlorine-loading interpretive approach. Second, the central importance of the ozone hole is demonstrated by the post-Montreal period, when the hole was definitively linked to CFCs, and a consensus emerged on both sides of the Atlantic that chlorine concentrations should be restored to their pre-hole levels. That analysis was first proposed by the EPA knowledge brokers and eventually led to the regulation of several other chemicals. During the Treaty revision process, the universal adoption of the chlorine-loading approach suggests that the hole was a key factor in the discursive shift both before and after Montreal.

The critique of the epistemic communities approach suggests that the relationship between science (and scientists) and policy (and policy-makers) is *multi-dimensional*, not uni-directional. Scientists might join together to influence the policy process, but their power is circumscribed by a host of contextual factors. Policy-makers may co-opt or manipulate the scientists, or they may simply ignore their advice. Alternatively, scientists may deliberately refrain from making controversial policy recommendations, as most of them did prior to Montreal, leaving the task of framing and interpretation to knowledge brokers.

81. Haas, *op. cit.*, in note 5, p. 202.

With so many possibilities, then, which factors are likely to produce which outcomes? Although no reliable generalisations can be derived from a single case, a careful reading of the ozone regime reveals some clues. The case is exceptional in that, prior to Montreal, there was a universally accepted scientific document with relatively narrow margins of uncertainty. Nonetheless, consensual knowledge did not engender epistemic cooperation. The shift to a precautionary discourse required alternative modes of framing the science that were independent of the atmospheric models. These modes derived their credibility from the perceived crisis represented by the Antarctic ozone hole. This finding is not new: perceived crises, from Torrey Canyon to Chernobyl, have often altered environmental policy. What the ozone case shows, however, is that policy change may presuppose a *discursive* shift, and that the *knowledge brokers* who forge that shift may be more influential than either political leaders or scientists.

The ozone case is not unique. The uncertainties involved in the expanded temporal and spatial dimensions of international environmental problems may invite the application of the precautionary principle. Certain discursive strategies lend themselves to precautionary action more so than others, and their credibility is enhanced by contextual factors, like the Antarctic ozone hole. Although the massive 'forest death' observed by West German scientists in the early 1980s was not conclusively linked to acid rain, it precipitated concerted action to reduce sulphur emissions in Europe. Likewise, the severe drought during the summer of 1988 lent credibility to a precautionary discourse on climate change, though clearly, no crisis of the proportions of the Antarctic ozone hole has yet appeared on the climate issue. This may suggest that a discursive approach is a fruitful research agenda for the future.

A discursive practices approach, in conceptualising power and knowledge as intricately related, moves beyond agent-centred social theory. The overarching regulation of the political field by linguistic symbols 'transcends the generative and critical capacities of any individual speaker or speech act'.[82] Discursive power is decentralised, non-monolithic, and rooted in linguistic practices, rather than overt control and material domination. An emphasis on discourse, rather than on states, bureaucracies, or individuals, interprets international regimes as loci of struggle among various networks of power/knowledge.[83] Unlike conventional approaches to epistemic communities, issues of framing, interpretation and contingency are central here, and *epistemic dissension* is at least as likely an outcome as epistemic cooperation.

If those scholars who discern a trend toward a 'post-industrial' or 'informational' world order are correct, then this argument has important implications not just for environmental issues, but more generally for the nature

82. Terdiman, *op. cit.*, in note 10, p. 39.
83. James F. Keeley, 'A Foucauldian Approach to Regimes', *International Organization* (Vol. 44, No. 1, 1990), pp. 83-106.

of power in the emergent global system.[84] A discursive approach is certainly more appropriate in a world increasingly characterised by 'modes of information' rather than 'modes of production'.[85] Furthermore, there are good reasons to believe that, as environmental pressures become more severe and other international problems become increasingly technical, the terms of political discourse will become ever more scientific. Yet, the prevalence of scientific discourse should not delude us into the common misconception that politics will therefore become more rational and less conflict-ridden, whether through functional or epistemic cooperation. A profusion of information could, in fact, lead to greater confusion, as the world becomes a ubiquitous market for discourses. The scientisation of politics may well devolve into the politicisation of science.

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84. International relations scholars have only recently turned their attention to the implications of post-industrialism for their field. See James Rosenau, *Turbulence in World Politics: A Theory of Change and Continuity* (Princeton, NJ: Princeton University Press, 1990).

85. Mark Poster, *Foucault, Marxism, and History: Mode of Production vs. Mode of Information* (Cambridge: Polity, 1984).