HARVARD UNIVERSITY
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Drawing Lessons About Science-Policy Institutions: Persistent Organic Pollutants (POPS) under the LRTAP Convention

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Environment and Natural Resources Program

Belfer Center for Science
and International Affairs

E-99-11

OCTOBER 1999

CITATION, CONTEXT, AND REPRODUCTION PAGE

This paper may be cited as: Eckley, Noelle. 1999. "Drawing Lessons About Science-Policy Institutions: Persistent Organic Pollutants (POPs) under the LRTAP Convention." ENRP Discussion Paper E-99-11, Kennedy School of Government, Harvard University. Available at http://environment.harvard.edu/gea. No further citation is allowed without permission of the author(s). Comments are welcome and may be directed to the author at the Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, 79 John F. Kennedy Street, Cambridge, MA 02138, telephone (617) 495-8132, fax (617) 496-0606, email: eckley@fas.harvard.edu.

The Global Environmental Assessment project is a collaborative team study of global environmental assessment as a link between science and policy. The Team is based at Harvard University. The project has two principal objectives. The first is to develop a more realistic and synoptic model of the actual relationships among science, assessment, and management in social responses to global change, and to use that model to understand, critique, and improve current practice of assessment as a bridge between science and policy making. The second is to elucidate a strategy of adaptive assessment and policy for global environmental problems, along with the methods and institutions to implement such a strategy in the real world.

The Global Environmental Assessment (GEA) Project is supported by a core grant from the National Science Foundation (Award No. SBR-9521910) for the "Global Environmental Assessment Team." Supplemental support to the GEA Team is provided by the National Oceanic and Atmospheric Administration, the Department of Energy, the National Aeronautics and Space Administration, the National Science Foundation, and the National Institute for Global Environmental Change. Additional support has been provided by the Department of Energy (Award No. DE-FG02-95ER62122) for the project, "Assessment Strategies for Global Environmental Change," the National Institute for Global Environmental Change (Awards No. 901214-HAR, LWT 62-123-06518) for the project "Towards Useful Integrated Assessments," the Center for Integrated Study of the Human Dimensions of Global Integrated Assessment Center at Carnegie Mellon University (NSF Award No. SBR-9521914) for the project "The Use of Global Environmental Assessments," the Belfer Center for Science and International Affairs at Harvard University's Kennedy School of Government, the International Human Dimensions Programme on Global Environmental Change, Harvard's Weatherhead Center for International Affairs, Harvard's Environmental Information Center, the International Institute for Applied Systems Analysis, the German Academic Exchange Service, the Heinrich Boll Foundation in Germany, the Massachusetts Institute of Technology's Center for Environmental Initiatives, the Heinz Family Foundation, the Heinz Center for Science, Economics and the Environment, and the National Center for Environmental Decisionmaking Research. The views expressed in this paper are those of the author and do not imply endorsement by any of the supporting institutions.

Publication abstracts of the GEA Project can be found on the GEA Web Page at http://environment.harvard.edu/gea. Further information on the Global Environmental Assessment project can be obtained from the Project Associate Director, Nancy Dickson, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, 79 JFK Street, Cambridge, MA 02138, telephone (617) 496-9469, telefax (617) 495-8963, Email nancy_dickson@harvard.edu.

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FOREWORD

This paper was written as part of the Global Environmental Assessment Project, a collaborative, interdisciplinary effort to explore how assessment activities can better link scientific understanding with effective action on issues arising in the context of global environmental change. The Project seeks to understand the special problems, challenges and opportunities that arise in efforts to develop common scientific assessments that are relevant and credible across multiple national circumstances and political cultures. It takes a long-term perspective focused on the interactions of science, assessment and management over periods of a decade or more, rather than concentrating on specific studies or negotiating sessions. Global environmental change is viewed broadly to include not only climate and other atmospheric issues, but also transboundary movements of organisms and chemical toxins. (To learn more about the GEA Project visit the web page at http://environment.harvard.edu/gea/.)

The Project seeks to achieve progress towards three goals: deepening the critical understanding of the relationships among research, assessment and management in the global environmental arena; enhancing the communication among scholars and practitioners of global environmental assessments; and illuminating the contemporary choices facing the designers of global environmental assessments. It pursues these goals through a three-pronged strategy of competitively awarded fellowships that bring advanced doctoral and post-doctoral students to Harvard; an interdisciplinary training and research program involving faculty and fellows; and annual meetings bringing together scholars and practitioners of assessment.

The core of the Project is its Research Fellows. Fellows spend the year working with one another and project faculty as a Research Group exploring histories, processes and effects of global environmental assessment. These papers look across a range of particular assessments to examine variation and changes in what has been assessed, explore assessment as a part of a broader pattern of communication, and focus on the dynamics of assessment. The contributions these papers provide has been fundamental to the development of the GEA venture. I look forward to seeing revised versions published in appropriate journals.

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Note: This paper was originally submitted in March 1999 as a senior honors thesis in the Environmental Science and Public Policy concentration at Harvard University. This is a revised version, which has been edited for distribution to GEA participants.

ACKNOWLEDGMENTS

In my research for this project, I have been fortunate to have been able to draw upon the support of numerous individuals during the past year. I offer special thanks here to several who, by giving their time, guidance, and insights, made the research and writing that went into this project a more productive, enjoyable, and meaningful experience.

My work at the U.S. Environmental Protection Agency during the summers of 1997 and 1998 formed the basis for my interest and explorations of persistent organic pollutants and the LRTAP convention. In Washington, Brian Muehling of EPA's Office of International Activities offered his perspectives and advice, as well as his file cabinets, to my research on the subject. Dr. Bruce Rodan's scientific perspective and exhortations to remember my governmental roots were greatly appreciated at key moments. When David Strother, Senior Advisor in EPA's Office of Pollution Prevention and Toxics, asked me in May 1997 if I knew what "POPs" were, I had no idea that two years later they would become my topic for a major research project. His wisdom, guidance, and mentorship have made my experiences in Washington truly extraordinary.

My deepest appreciation to all the participants of the Global Environmental Assessment project here at Harvard, both fellows and faculty, who welcomed me into their discussions, classes, and seminars, and gave me invaluable insight into academic discourse. I offer a special thank you to Nancy Dickson, whose assistance, support, and kindness over the past year has been very much appreciated. Had it not been for her strong encouragement, as well, I never would have thought it was possible to travel to Geneva to do this research. Stacy VanDeveer offered his wisdom and notes from the POPs negotiations and numerous comments on my research design; his behind-the-scenes guide to LRTAP negotiations was right on target.

For making my field research possible, I thank Prof. Jim McCarthy and the Environmental Science and Public Policy concentration, as well as the Global Environmental Assessment Project.

I owe a debt of gratitude to Terry Keating, AAAS Fellow in EPA's Office of Air and Radiation, for his help in getting me access to the negotiations. I am especially grateful to the members of the U.S. Delegation to the LRTAP Executive Body meeting -- John Beale, Bill Harnett, and Kimber Scavo from the U.S. EPA, and Mike Metelits from the U.S. Department of State -- for welcoming me so warmly to the delegation during my time in Geneva. Thanks to all who gave their valuable time to be interviewed for this project -- in Washington, D.C., in Geneva, and in the Netherlands.

I have much appreciated Bonnie Robinson's organizational wisdom, scheduling miracles, and help in managing day-to-day crisis. At the Environmental Science and Public Policy concentration, Lorraine Maffeo has been a cheerful source of wisdom and counsel over the past three years; I can't imagine ESPP without her.

And, of course, to my advisor, Prof. Bill Clark: from the day almost a year ago when I came to him with the beginnings of a research question, his excitement, enthusiasm, support, and humor have kept me going. His unique perspectives and pointed questions have made me think. I'm looking forward to more fruitful collaboration in the future. Many thanks.

ABSTRACT

As transborder environmental issues become more complex, international negotiations to address them increasingly rely on scientific and expert information to provide information to policymakers. In designing the processes by which expert advice will be taken into account in negotiations, policymakers often look to similar types of processes informing other environmental issues, in search of lessons for application to the issue at hand. Though it is generally accepted among those involved in such processes that some agreements have incorporated expert advice more effectively than others, there is little systematic evaluation by policymakers or academic analysts of the factors that lead to effectiveness across different issues. It is difficult to determine what, if any, lessons might best be drawn from these previous experiences, and there is disagreement even about what constitutes effectiveness. This paper sets out to explore which processes of incorporating scientific advice into international decisionmaking might be transferable over very different issue areas. In order to identify such processes and properties, it will examine in detail the ways in which expert information was taken into account in negotiating three protocols to the Convention on Long-Range Transboundary Air Pollution (LRTAP): the 1985 and 1994 protocols on sulfur emissions, and the 1998 protocol on persistent organic pollutants (POPs).

I will argue that the LRTAP POPs assessment process and the assessment processes that informed the 1985 and 1994 sulfur protocols exhibited common dimensions of effectiveness, and that these dimensions of effectiveness were influenced by a common set of variables. Effectiveness in these three LRTAP protocols will be examined by analyzing the incidences in the negotiations where scientific information facilitated agreement on issues, or served to stall the process of the negotiations. This paper examines the common elements which participants found helpful in POPs assessment processes with those found helpful in previous LRTAP protocols, in order to determine whether there are common principles that emerge to explain the effectiveness common in both cases. This comparison identifies a few key elements that might serve to explain the above, including the adaptability of the assessment process and the iterative nature of communication between scientists and policymakers. For example, where scientists and policymakers were able to communicate repeatedly about assessment procedures and outcomes, and where adaptability allowed policymakers to make science-based decisions on actions with confidence that they would be later revisited, scientific assessment processes were more effective across the different issues of sulfur and POPs. This paper concludes by examining the questions that these findings might raise for other international environmental agreements seeking to design effective ways for science to influence negotiations, and proposes hypotheses for policymakers and analysts that might guide application of these results to other environmental issues.

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ACRONYM LIST

EMEP	European Monitoring and Evaluation Program
GEA	Global Environmental Assessment Project
HELCOM	Helsinki Commission
IIASA	International Institute for Applied Systems Analysis
LRTAP	Convention on Long-Range Transboundary Air Pollution
NGOs	Non-Governmental Organizations
NOx	Nitrogen Oxides
OECD	Organization for Economic Cooperation and Development
PARCOM	Paris Commission
POPs	Persistent Organic Pollutants
RAINS	Regional Acidification Information and Simulation model
RIVM	Institute for Public Health and the Environment, Netherlands
UN-ECE	United Nations Economic Commission for Europe
VOCs	Volatile Organic Compounds

1. QUESTIONS AND CONTEXT

"Modeled after the Montreal Protocol." This was an oft-quoted saying among delegates to the second session of the Intergovernmental Negotiating Committee to develop a global agreement on persistent organic pollutants (POPs), in January 1999, about how the POPs agreement will be developed (ENB 1999). Delegates negotiating agreements like the POPs convention often look to existing agreements – including the Montreal Protocol on Substances That Deplete the Ozone Layer – for guidance in designing elements of international environmental regimes. It is unclear in many cases, however, how these lessons of previous agreements may *best* be adapted to or incorporated into the next generation of environmental negotiations. Given that negotiators often adopt elements of previous agreements, how can they draw parallels more critically and reflectively? To what extent does lesson-drawing improve such negotiations, and which elements of agreement are applicable to a wide range of processes?

A particular area of contention about which negotiators often draw lessons from previous experience is the design and implementation of processes for incorporating scientific and expert information into decisionmaking. It is generally accepted among those involved in such processes that some agreements have incorporated expert advice more effectively than others; that is, some of these processes have worked well, in participants' estimations, and some have been less successful. A wide range of processes exist for the provision of scientific and expert advice on increasingly complex environmental problems: negotiations can be informed by expert groups developing policy-targeted reports; by scientists who steer far clear of policy recommendations; by policymakers analyzing existing scientific documentation; through existing or *ad hoc* groups, or no groups at all. It is difficult to determine which are the best lessons that can be drawn from these previous varied experiences when the next transborder environmental issue is to be addressed. Since different environmental negotiations are generally based on very different scientific and political qualities, determining which frameworks for scientific and expert advice can be transferred successfully becomes ever more complex.

This paper sets out to explore what qualities of transnational scientific advice processes might contribute to effectiveness over a broad range of issue areas. In asking this question, it seeks to analyze whether any sort of template or collection of determinants exists that influences the effectiveness of scientific advice processes over different sorts of issues. Therefore, it seeks to determine what the best lessons might be for policymakers to draw on the matter of scientific advice processes. Clearly, a process which adopted *in toto* all of the institutions, processes, and constructs of scientific advice in another issue area, without regard to context, would compromise its ability to incorporate expert advice effectively; in contrast, it is equally improbable that each issue must develop such processes in isolation, without the benefit of previous experiences, and disregarding as issue-specific all qualities which might have influenced effectiveness in other forums. Some subset of these qualities is likely to influence effectiveness over a wide range of issue areas.

In seeking to analyze the effectiveness of a scientific advice process empirically, one is faced with material from a wide variety of international environmental agreements, all of which used science in various ways and to various different effects. In order to study how effectiveness varies when

processes of scientific input are borrowed across issue areas, it would be ideal to find a case in which scientific advice processes were adopted fully from other negotiations. However, since such processes are clearly a product of unique international and diplomatic contexts, it is difficult to find a case in which the final negotiated structure of the scientific advice process is very comparable. This is because even if delegates initially adopt without modification the elements of scientific input from another agreement, the dynamics of international negotiation virtually ensure that such a proposal will be substantially changed by the time it is implemented.

In one recent example, however, international negotiations addressed an environmental issue in a context and within a framework that has developed around very different sorts of issues. This is the case of one of the most recent protocols to the Convention on Long-Range Transboundary Air Pollution: the 1998 Aarhus Protocol on Persistent Organic Pollutants (POPs).

The Convention on Long-Range Transboundary Air Pollution (LRTAP) is one of the agreements often cited for effective use of science in negotiations (Levy 1995). Countries of the United Nations Economic Commission for Europe (UN-ECE) signed the LRTAP convention in 1979. Over its twenty-year history, LRTAP has addressed transboundary environmental concerns such as acidification, eutrophication, and photochemical oxidation. The LRTAP convention now includes protocols on sulfur emissions (1985 and 1994), nitrogen oxides (1988), and volatile organic compounds (1991). The signing in June 1998 of the protocol on persistent organic pollutants (POPs), as well as a protocol on heavy metals, represented a departure for LRTAP from traditional air pollution issues, in addressing a problem of very different qualities from sulfur and nitrogen, and even from volatile organics. Persistent organic pollutants are compounds whose properties of high toxicity, persistence in the environment, and bioaccumulation in living organisms make them a risk to the environment and human health at distances far from the locations of their use and emission. In contrast to sulfur, which can be traced using atmospheric models in a relatively straightforward way from emission to deposition, POPs can revolatilize from sites of deposition. Therefore, definitive links between the source of POP pollution and the location of effects are very difficult to determine. Where the effects of acidifying pollutants such as sulfur are relatively observable in the environment, POPs exert often unseen toxic effects on the environment and human health. And where previous LRTAP protocols addressed unwanted byproducts of industrial processes, POPs include many commercially produced chemicals – chemicals, such as pesticides, that were designed and produced for the very properties that make them of environmental concern.

These differences, coupled with the addressing of POPs under the framework of the LRTAP convention, make examining the case of the POPs protocol to LRTAP a useful test for determining how frameworks for incorporating expert advice might translate over different issues. The POPs experience shares with other protocols to the LRTAP convention its institutional context and structure; however, in negotiating the POPs protocol, science was incorporated in very different ways from those in other LRTAP protocols. By analyzing the similarities and differences in the processes which sought to incorporate science into these different protocols, and the relative effectiveness of these processes, it may be possible to draw conclusions about the qualities that might influence effectiveness over a range of issue areas -- and provide an empirical basis of inference for those who seek to learn from previous experiences.

The question of how lessons of previous experience might best be adapted to different policy issues is common yet important in analysis of public policy. For example, Rose (1991, 1994) has examined the ways in which lessons are drawn from existing programs; Neustadt and May (1986) have looked at how policymakers have drawn lessons from history. In the specific case of scientific advice processes, it is still unclear which specific elements of such processes may successfully be copied over a range of issues, and which are indeed specific to the issue at hand (GEA 1997). Examining the lessons that might be learned regarding scientific advice processes is a specific case of this general question.

This paper will look in depth at the processes which incorporated science into the negotiations of the persistent organic pollutants (POPs) protocol to the LRTAP convention, and compare this experience to similar processes in other LRTAP protocols, specifically the 1985 and 1994 sulfur protocols. It will analyze the degree and characteristics of assessment effectiveness in the POPs protocol against the experiences of other LRTAP protocols, examining in this context previous scholarship on the LRTAP convention (e.g. Hordijk 1991; Levy 1993; Levy 1995; Cowling, 1982; VanDeveer 1998; etc.). It will then compare the POPs and sulfur protocols in order to determine what might have influenced the effectiveness of scientific advice processes, analyzing elements of process and institution as well as issue-specific characteristics. Data for this comparison will be drawn from personal interviews conducted in 1998 with negotiators and scientists involved in the assessment and negotiating processes for the LRTAP protocols considered. In addition, primary documentation including assessment reports, meeting documents, and written communications among parties will also be analyzed, particularly for the POPs protocol. The results of this examination will yield a set of determinants that have influenced the effectiveness of LRTAP's scientific advice processes over a broad range of different issue characteristics. These determinants, properties of design of assessment processes, can serve as a concrete basis for asking questions and generating hypotheses about what might influence effectiveness in other international environmental agreements that seek to incorporate scientific advice.

Defining what constitutes effectiveness of scientific input into the policymaking process is extremely difficult. Effectiveness can, in fact, be defined in many different ways. Different actors in the policy process often have different conceptions of what they consider effective; analysts as well vary in what they mean by effectiveness. One could choose to evaluate, for example, political effectiveness, environmental effectiveness, or cost-effectiveness. Even given a choice of what is meant by effectiveness, there is no easy way to measure what is effective, and what is ineffective, in a context in which issues are complex, difficult, and spread out over time. In analyzing effectiveness, this paper will develop and utilize a framework for analyzing the effectiveness of the use of scientific and expert advice in the particular case of the LRTAP convention, based upon existing theories of effectiveness in policy design and in scientific assessments (e.g. Keohane et al. 1993; Keohane and Levy 1996; Clark et al. 1996; Clark and Majone 1985, Majone 1980, Ravetz 1971).

The analysis in this paper will be structured as follows: first, section 2 will set out and analyze different views of how one might conceptualize ideas of policy learning, effectiveness, and the determinants of effectiveness in assessment processes. Drawing upon these theories, it will set out a framework under which effectiveness and its determinants may be analyzed under the

LRTAP convention. In addition, it will establish a candidate list of the types of variables that might influence assessment effectiveness, as well as their analogues in this specific case. Section 3 will address the question of how effective the processes for incorporating scientific advice into negotiations actually were in the LRTAP protocols. It will use the framework developed in section 2 to analyze the POPs experience, and compare this experience to the use of scientific information in the 1985 and 1994 sulfur protocols. Section 4 will then analyze the determinants that contributed to the relative degree of effectiveness with reference to the candidate determinants set out in section 2, and trace out the ways in which these candidates might in practice influence the effectiveness of an assessment process, with specific examples from the POPs protocol and the sulfur protocol experiences. Section 5 will conclude by identifying the determinants that in these cases are responsible for influencing effectiveness over a range of issue characteristics, and raising questions about what these findings might mean for the design of such processes in other international environmental negotiations. It will analyze the utility and applicability of the conception of effectiveness employed in this paper, and generate hypotheses about what variables influence assessment effectiveness over a range of issue areas, which might serve to guide policymakers and analysts in lesson-drawing.

2. FRAMEWORKS FOR ANALYSIS

The goal of this paper is ultimately to explore how policymakers might better incorporate lessons from previous scientific advice processes in designing more effective avenues for future transnational assessment activities. In order to identify the key influences upon the effectiveness of assessment processes, however, it is necessary to begin with a clear idea of what is meant by effective use of science in international negotiations. Building on theoretical analyses in public policy and international relations, this section will develop criteria for evaluating the effectiveness of an assessment process that can be applied specifically in the cases of LRTAP protocols. It will conceptualize and categorize ways in which elements of an assessment process might influence effectiveness, as well as establish candidates for these elements that might apply in LRTAP protocols. It will put forth a way of analyzing the processes by which these elements might influence effectiveness, and propose a framework for appraising their relative influences. Finally, it will explore the conceptual basis of how policy learning might occur in processes that seek to adopt or adapt elements of previous experience.

2.1. Science, Policy, and Assessment

Before one can go about determining what makes an effective assessment, it is important to be clear exactly what is meant by the terms science, policy, scientific advice processes, and assessment. Indeed, in any forum that seeks to incorporate technical or expert information into societal decisionmaking, the categories of what might be considered "science" and what is "policy" are considerably blurred. An increasing role for science, especially in decisionmaking on environmental issues, has made the way in which science regularly influences policy choices increasingly complex. The problem of how best to incorporate scientific information into decisionmaking processes is hardly one specific to this case, or even to the international environmental context. Theories of science and policy have described and categorized this interaction as a social process. An important foundation for these examinations was the

characterization of the realm in which science and policy combine as the domain of "trans-science" (Weinberg 1972). "Trans-scientific" issues were defined by Weinberg as those for which "questions...can be asked of science and yet which cannot be answered by science." Sheila Jasanoff has argued that the negotiation of boundaries between policy and science and the definition of the categories themselves play an important role in the debates and resolutions of questions which have both scientific and political components (Jasanoff 1987). Defining the domains of science and policy and conceptualizing the ways in which science is taken into account in making policies are fraught with complications. In the case that will be examined here, the LRTAP convention, the negotiation of boundaries between science and policy has indeed been a key influence in the process of developing protocols. However, the large degree of consensus on collaborative science that is a hallmark of the LRTAP process means that an in-depth examination of the categories of science and policy themselves would not add measurably to analysis of the issue at hand. Science and policy, and the negotiation of boundaries, are therefore better addressed in this specific case by looking at the ways in which these sorts of debates are engaged in practice.

In order to address the ways in which these scientific advice processes work in real-world, transnational contexts, it is necessary to acknowledge that the categories of science and policy are problematic ones. However, working from a clear definition of scientific advice processes is useful. A particularly helpful definition of science-policy assessment can be gleaned from the work of the Global Environmental Assessment (GEA) project. The GEA project has defined assessment as "the entire social process by which expert knowledge related to a policy problem is organized, evaluated, integrated, and presented in documents to inform policy or decision-making." This definition conceives of assessment as a process that bridges expert knowledge and policy and seeks to inform policymakers (GEA 1997). The GEA definition of assessment will be adopted here because it encompasses a full range of advice processes that seek to incorporate science into policy, while explicitly acknowledging the social basis and character of these processes.

2.2. Measuring Effectiveness

Given this definition of assessment, judging the effects of such a process on policymaking becomes a next question; this is another area of much existing analysis. Analyzing the effects of assessment on policymaking draws much from examinations of the difficulties of determining effects of any sort of process on policy outcomes. However, in many cases it is possible to hypothesize a causal linkage between aspects of the assessment process and observable outcomes. Such outcomes are analogous to the outcomes of any influences on public policy: for example, an issue can be placed on or off the agenda; the positions of actors in bargaining processes can be changed; or a policy decision can be made. It is clear in many cases that assessment processes can indeed have these outcomes.

A focus on "effectiveness," however, introduces a normative dimension to discussions of effects. There are several different ways of defining effectiveness in the context of international environmental issues. For example, when asked whether he thought that incorporation of expert advice into POPs protocol negotiations was successful, one delegate responded, "Well, I hate to

sound like Clinton, but it depends on what you mean by successful."[1] Effectiveness, like success in this sense, is a contested term.

One classification of different ways to conceptualize the effectiveness of international institutions has been put forth by Young (1992, 1996). Young defines effectiveness generally as a measure of the role institutions play in shaping behavior in international society, and writes that "Institutions are effective to the extent that their operation accounts for the variance in individual and collective behavior observable across spatial or temporal settings" (1992). This definition of effectiveness as the output of international processes leads to a classification of six dimensions of effectiveness: effectiveness in problem-solving, or whether institutions operate in solving those problems which spurred their creation; effectiveness as goal attainment, the extent to which the goals of the institution are fulfilled; behavioral effectiveness, whether an institution causes its members to alter their behavior; process effectiveness, which represents the extent to which an international institution's rules are implemented on a national level; constitutive effectiveness, whether the institution gives rise to social practices among members; and evaluative effectiveness, a measure of the outcomes or consequences of the institution (Young 1996). These dimensions of effectiveness look at the practical consequences or outcomes of international institution formation.

Another outcome-based conception of effectiveness is described by Victor *et al.* (1998) in their examination of the implementation of international environmental agreements. Victor *et al.* define "effect" as "the extent to which the accord causes changes in the behavior of targets that further the goals of the accord." They see evidence for "effectiveness" in the actual behavioral changes caused by the agreement. Kay and Jacobson (1983) view the effectiveness of environmental protection activities with respect to five sets of questions, relevant to the goals, attitudes, achievements, and impacts of the agreement and its participants. These ideas of effectiveness look retrospectively at the ultimate effects of international institutions.

In their examination of international environmental issues, Keohane *et al.* (1993) note, "Truly effective international environmental institutions would improve the quality of the global environment," but acknowledge that the lack of long-term environmental quality data makes analyses of environmental effects difficult at this stage in addressing the issue. Instead, they look to the "observable political effects of institutions." Keohane *et al.* choose to measure the effectiveness of international environmental institutions by examining their effects on increasing what they term the "three Cs": *concern* about the issue, the *contractual environment*, and the *capacity* to address the problem. They envision the "three Cs" as a causal pathway by which to analyze the impact of international institutions on environmental quality; that is, any increase in the "three Cs" represents an increase in effectiveness of international institutions. These criteria are applied again to analyze environmental aid programs (Connolly 1996).

The common basis of these several different conceptions of effectiveness is their emphasis on outcome-based measures. In analyzing a negotiation such as the LRTAP convention, however, it is difficult to distinguish elements of agreement as outcomes, because of the particularly iterative nature of the LRTAP process. In addition, the POPs negotiation is too recent to enable a clear evaluation of the protocol's outcomes. Therefore, it would be difficult to apply this type of criteria of effectiveness to LRTAP convention in general, and the POPs protocol in particular.

A different way of conceptualizing effectiveness, in the case of scientific input into public policy, comes from Clark and Majone (1985). They propose that scientific input into the policy process be evaluated against a set of four "metacriteria": adequacy, effectiveness, value, and legitimacy. In this formulation, the criterion of effectiveness asks the question, "Does scientific inquiry actually help to solve practical problems?" They also identify three different "critical modes" of examining scientific inquiries in policy contexts: input, output, and process. Their process mode, which they identify as "the most subtle and informative" form of evaluation, emphasizes institutional structures, procedures, and participation. Their idea of effectiveness, as well, depends on a progressive conception of measuring effects on the policy agenda. Clark *et al.* (1996) have applied the Clark and Majone criteria of adequacy, effectiveness, value, and legitimacy to the "blue book" assessments of stratospheric ozone depletion.

The appeal to process- and progress-oriented evaluation of effectiveness by Clark and Majone (1985) provides a helpful basis from which a framework for analyzing effectiveness in LRTAP protocols might be built. Because of the difficulty in distinguishing outcomes in the LRTAP convention, it is useful to look at impacts on process when evaluating the effectiveness of the assessment process in negotiating protocols. The Clark and Majone criterion of effectiveness builds from the ideas of progressivity in analysis of scientific research programs by Imre Lakatos. Lakatos conceived of paradigm changes in scientific research programs as "progressive problemshifts" -- that is, a program is progressive if it retains predictive capacity (Lakatos 1971). Majone (1980) used ideas of progressivity in applying Lakatos' theories to policy work. Majone adapted Lakatos' ideas by using the ideas of progressive problemshift to counter the phenomenon of "little effect," and he applied this idea to evaluation of policy action programs. In Majone's interpretation, an action program is progressing if it solves or ameliorates the problems another could not; that is, if it is able to move issues from a stage of contention to a stage where actors consider them resolved.

This formulation is particularly helpful in the context of the LRTAP convention because it fits well with the structure of the convention itself. Protocols to the LRTAP convention are negotiated in succession: the initial framework convention was followed by "first generation" protocols requiring specific cuts, to be followed by further reductions in "second generation" protocols. The process -- and even the often-used terminology of generations -- shows that the LRTAP convention is not merely an instrument but a comprehensive process. In addition, focusing on the LRTAP protocol negotiations eliminates many of the difficulties that face those who seek to design criteria that evaluate assessments in general. For example, the LRTAP context includes only the United Nations Economic Commission for Europe (UN-ECE) region (Europe, the former Soviet states, the U.S., and Canada) and therefore does not encompass countries, such as developing countries, in which incorporating science into policy can be structurally very different. For these reasons, a conception of effectiveness that takes into account how issues in the LRTAP process are progressing is most useful in analyzing the role of science in LRTAP's protocols. Effectiveness in this sense will address not the ultimate environmental influences of the agreement, but the role that scientific advice played in the policy process. This idea of effectiveness, in addition, does not consider a scientific advice process effective if the conclusions of scientists are adopted by policymakers; it instead conceptualizes effective science as that which, taking its cue from those who speak of progressive problemshifts, moves the policy process forward.

What, however, is meant by the phrase "moving the policy process forward?" The process and progress of making public policy has been disaggregated into stages by numerous analysts in different ways. In his framework for analyzing international environmental institutions, Keohane (1996) identifies five phases of problem solving: collective problem definition, solution specification, mechanism specification, mechanism implementation, and solution implementation. The view of policy processes as a sequence of phases is a common one, and similar disaggregations of the policy process have been used in analysis by Jones (1977) and Kingdon (1984). The advocacy coalition framework of Sabatier (1993) provides another model within which to conceptualize policy change -- a framework which views policy change over long timescales based on the interactions of "policy subsystems" acting in the same manner as belief systems.

A stage-oriented model of the policy process seems to fit best with the way negotiation on particular LRTAP protocols works in practice. In analyzing the role of science in the LRTAP negotiations, the stages of the policy process that will be analyzed include the first three of the phases identified by Keohane (1996). Implementation, though extremely important in the LRTAP convention and science processes, will not be analyzed here. One of the main reasons for omitting implementation from this analysis is that the LRTAP POPs protocol is so recent that data on implementation is not yet available. Instead, the analysis of effectiveness in this paper will look specifically at the policy process from the agenda-setting stage through the decision to take action through signing a protocol, stages of the process that can be compared across the LRTAP sulfur and POPs protocols.

Given a model of the policy process that views policy progress as a cycle through stages of decisionmaking, how is it possible to tell whether the policy process is moving forward, at a specific moment in time, or whether it has stalled? In a general sense, classifying policy progress or stagnation is extremely difficult. However, in the specific case of the LRTAP convention, an iterative process marked by successive negotiation, one can classify the degree of progress anecdotally. As a hypothetical example, one could imagine participants in LRTAP protocol negotiations expressing discontent at negotiations seemingly stalled by a point of technical disagreement; in contrast, participants could indicate optimism that agreement, or even a protocol, is ahead in a foreseeable horizon. Whether negotiations, in the opinion of a variety of different participants, are moving ahead with sufficient speed (or, in contrast, with sufficient deliberation) also can serve as an anecdotal way to conceptualize progress.

Analyzing scientific assessment processes in general can never be clear-cut. By an examination of the utility of assessments to negotiations, however, it is possible to view scientific advice as a process among many that can influence policy decisions, while recognizing that science can serve a special function in decisionmaking on transnational environmental issues. Jasanoff (1990) writes of scientific advisory bodies as providing a "serviceable truth: a state of knowledge that satisfies tests of scientific acceptability and supports reasoned decisionmaking, but also assures those exposed to risk that their interests have not been sacrificed on the altar of an impossible scientific certainty." The concept of serviceability explicitly acknowledges that scientific information and analysis, the "truth" sought in many assessment contexts, is not objectively verifiable, but a product of social construction. In determining the effectiveness of a process in which there is no objectively verifiable standard, therefore, the appeal to process-based evaluation acknowledges the lack of objectivity, but also provides a way in which assessments

can be analyzed. It may be impossible to determine whether the science that goes into a policy process is indeed "truth," but it is possible to examine the extent to which it has a progressive influence on policy. Asking about the effectiveness of assessment processes attempts to sharpen analysis of how well scientific advice supports reasoned decisionmaking. A progressive conception of effectiveness is one way of getting at the question, are some assessments more "serviceable" than others? It is also an attempt to add a temporal dimension to the concept of "serviceability." The "serviceable truth," therefore, becomes not a single state of knowledge but the product of a dynamic, ongoing negotiation among scientific acceptability, decisionmaking, and interest; progressing through this negotiation becomes the test of serviceability.

Though the concept of progressivity as used here builds upon theories of scientific research programs and policy analysis, there is no substantial basis of theory on which to base the use of this concept to evaluate scientific assessments. However, using a progressive conception of effectiveness, it is possible to delineate a method for evaluating the effectiveness of scientific advice processes that can be applied in the case of LRTAP protocols. Clearly, any criteria of effectiveness depend on the identity of the evaluator. That is, one must define effectiveness "for what" (i.e. for what purpose) and effectiveness "to whom" (from whose perspective). In analyzing the scientific advice processes in LRTAP protocols here, a progressive conception of effectiveness distinguishes effectiveness for further policy development. The following analysis will focus on the participants in the international negotiating processes, who are the policy actors most involved in the process that led to policy progress.

In designing a method to evaluate effectiveness conceptualized as policy progress, it is helpful to classify some general ways in which scientific assessments can contribute to issue progress, as well as some ways in which assessments can stall progress. One way in which science can contribute to issue progress is by *establishing a basis of common understanding* and agreement from which policymakers can agree to move action to a next stage of issue evolution. For example, this could occur in a case where scientific understanding contributes to getting an issue on the agenda. A particular case of this, in the LRTAP POPs protocol, will be discussed in section 3. Science can also provide a basis for understanding by facilitating a decision to move ahead to a decisionmaking stage, or to take a decision on action options. The basis-setting function of scientific assessment is related to Majone's idea of "core" commitments in action programs. Majone, citing Lakatos' theories of research programs, writes that policy action programs are held together by a central core of value commitments. He writes, "If a programme is not to be abandoned at the first signs of difficulty, the core must be made (temporarily) immune to criticism by a common decision of the participants in the policy process" (1980). It is by establishing this sort of core that scientific assessment can form the basis for further policy action. A second way in which scientific assessments can contribute to issue progress is by *providing evidence that can justify decisionmaking*. The existence of science that serves this justification function can give policymakers what they feel is authoritative reason for proceeding. An example of this type of progressive function can be seen in the scientific analysis that established transport pathways in early modeling of acidifying compounds in the LRTAP context, which indicated the sources of acidifying pollutants. A third way in which science can facilitate progress is by *focusing and channeling debate*. The idea of channeling debate builds on the criterion of adequacy put forth by Clark and Majone (1985), based on theories of adequacy in scientific research programs by Ravetz (1971). Ravetz describes a mature field of inquiry as one

that can channel debates on well-defined problems, or can provide an agreed-upon foundation for debate. Assessment that provides such a foundation can help to focus policy discussion and channel the policy process to solve disputes. A particular type of channeling occurs when assessment provides a common method of analysis for policies and impacts -- a common language through which options and outcomes can be communicated. This is perhaps most exemplified by the "critical loads" approach to the second LRTAP sulfur protocol, which will be described in more detail in section 3.

In contrast to these examples of how science can facilitate progress, there are several ways in which science can stall issue progress. By *promoting excessive scientific debates* over peripheral issues, or overemphasizing scientific uncertainties, scientific assessment processes can prevent policymakers from establishing a consensus that pushes action forward. A hypothetical example might be if scientific and assessment discourse were so consumed with the question of whether a particular exposure standard for a certain chemical were justified that no action was taken, despite agreement that the substance was harmful at currently occurring exposures. A second way in which science can stall policy progress is through *failing to provide evidence* that is convincing, credible, and reliable, upon which policymakers could base their decisions. A particular example of this can be seen in scientists' reluctance to release any information about issues until they are satisfied that they know all angles of the issue. In order to see this, one could look at what might have happened in negotiations of the Montreal Protocol had debates over the emerging and controversial science of the Antarctic ozone hole been the focus of assessments, rather than the more known quantity of temperate latitude ozone depletion. Clark *et al.* (1996) argue in their examination of the "Blue Book" ozone assessments that the decision to let scientific analysis rest on the relatively known elements of conventional scenarios, and not to address in detail the uncertain domain of Antarctic ozone science, was a critical one influencing the success of this assessment. It is easy to imagine, however, an assessment process in this case that compromised its legitimacy, and perhaps the process itself, by allowing uncertainty over the Antarctic ozone hole to overshadow consensus on other aspects of the ozone depletion problem. A third way in which scientific assessments could stall negotiations is by *shifting debate to methodological controversies.* In this case, instead of channeling debate to analysis on a common basis, assessments lead to controversies that lack such focus. Ravetz (1971) characterizes immature fields as those in which "controversies on results range indiscriminately and inconclusively from criticism of raw data to abstract methodology." Policymakers might, for instance, engage in excessive debates over classification of problems, without ever reaching the stage of addressing those problems. This could cause policymakers to focus on issues external to environmental impact but controversial in the process. One could imagine a scenario in which debate over "critical loads" stalled the process in this way, if policymakers proceeded to conduct negotiations based on not one but several competing methodologies for calculating such numbers.

Evidence from LRTAP documents and interviews with participants in LRTAP negotiating processes can yield a set of instances in which scientific information played a role in influencing the progress of the negotiations. In these instances, some quality of the scientific assessment process was responsible for either slowing or moving forward the progress of the issue at hand. If issue progress is taken as a definition of effectiveness, then the effectiveness of LRTAP protocols may be measured by comparing the instances in which scientific advice stalled the policy process, and contrasting these with the instances in which scientific advice helped to move the policy process forward. Referring to the characterization of ways in which science can influence progress that is outlined above can facilitate this analysis. This characterization is

summarized in Table 2.1. This paper will analyze the relative degrees and dimensions of effectiveness of science in LRTAP protocols in this way, by examining, classifying, and comparing the examples of science influencing policy progress.

2.3. Contributors to Effectiveness

Once the relative effectiveness of scientific advice in the LRTAP protocols has been analyzed, a next step is determining what aspects of the assessment process could be considered contributors to this degree of effectiveness. Many different qualities of institutions, and elements of processes, could have an influence on effectiveness. Kay and Jacobson (1983) classify influences on effectiveness into five categories of variables: the nature of the problem considered, the structural characteristics of institutions, the secretariats or bureaucracies of international institutions, the policies of governments and relevant actors, and the configuration of governments and other actors. In classifying influences on behavioral effectiveness, Victor *et al.* (1998) look also to the nature of the problem, and also to configurations of power, the nature of commitments, linkages to other issues and objectives, exogenous factors (such as economic conditions, the role of individuals, or the existence of "focusing events"), and public concern. Young (1996) separates influences on effectiveness into endogenous, exogenous, and linkage variables. Endogenous variables are those characteristics of institutional arrangements themselves, exogenous variables are factors such as social forces which influence international society in general, and linkages the institutional arrangements which define the relationships between endogenous and exogenous variables. Similarly, the GEA project has identified and classified aspects of the assessment process that it sees as key elements influencing outcomes. These aspects fall into the broad categories of *context, content, and process* (GEA 1997). *Context* is the background against which assessment occurs, and can include scientific, political, and economic factors. Elements of *content* include the material actually conveyed in an assessment, and many variables that might be thought of as issue-specific. *Process* involves the way in which the assessment is carried out, from design to participation to communication (GEA 1997).

Delineating types of influences on effectiveness into categories, such as those of *context*, *content*, and *process*, provides a useful framework for categorizing the different influences on effectiveness in LRTAP protocols. One can identify -- from previous studies of assessment in general, other examinations of LRTAP protocols, and empirical evidence from the POPs protocol -- specific elements of LRTAP's assessment processes that might be influences on their relative degrees of effectiveness. Some are elements which represent attributes shared among POPs and earlier LRTAP protocols, and some are unique to either the POPs protocol or one or another of the previous LRTAP protocols.

Variables influencing the effectiveness of assessment in LRTAP protocols might include the setup of the institutional structure or the flexibility of that structure. These sorts of variables might helpfully be viewed as those of *context*. The broad institutional context for LRTAP protocols is the UN-ECE region. LRTAP has a relatively flexible working group structure that has changed over time; Levy (1993) argues that the organization of working groups around environmental damage rather than emission sources is responsible for the ease with which different sorts of air pollution issues entered LRTAP's agenda. Variables influencing

effectiveness that might fall under the category of *content* might include the relative 'ease' for national implementation of an issue, or the ability to tie sources definitively to effects. Kay and Jacobson (1983) note these under their description of the nature of the problem being considered. These are also "issue-specific" characteristics -- those that can vary greatly between different environmental issues in the LRTAP context. Variables that could be considered those of *process* include the iterative nature of the LRTAP convention, participation of NGOs, the flexibility of the instrument for future change, the relative internationality of the assessment activity, or the existence of shared commitments to action.

2.4. Pathways for Influencing Effectiveness

After identifying variables that might influence effectiveness, there is a need for a model to conceptualize how these variables might influence effectiveness in practice. In looking at an outcome-based view of effectiveness, Levy et al. (1993) identify several pathways to effectiveness, including institutional activities such as facilitating issue linkages, collecting scientific knowledge, providing bargaining forums, conducting monitoring, increasing national accountability, and transferring financial assistance and expertise.

In the case of LRTAP protocols, two particular concepts emerge as key pathways through which characteristics of process tend to influence the effectiveness of assessment processes, as effectiveness is defined in this analysis. These are the concepts of *credibility* and *relevance*. In this analysis, credibility and relevance can be treated as intermediate variables; variables of context, content, and process can influence the credibility and relevance of assessment processes; credibility and relevance then enable the issue to proceed effectively. These variables are summarized in Table 2.2. *Credibility*, as used here, denotes the authoritativeness of information used in the policy process, whether scientific or political, with reference to specific actors. *Relevance* addresses the utility of such information for policymakers, and its pertinence to the issue at hand.

In order to see how variables of context, content, and process can contribute to effectiveness through influencing assessment's credibility and relevance, it is helpful to trace examples of how this might occur. One can trace anecdotally a causal pathway between an element of the assessment process and an ultimate change in the progress of the negotiations. The conceptualization of such a path might draw from the concept of "pitfalls" raised by Ravetz (1971). Ravetz examines the progress of scientific knowledge, and uses the concept of "pitfalls" to analyze how well scientific work is progressing: work well done avoids the commonly-recognized pitfalls that have plagued others.

This concept is particularly relevant to the domain of assessment. Past research and participant experience can identify common pitfalls of assessment (e.g. GEA 1997). The skillful avoidance of these pitfalls can be seen as a causal mechanism for influencing effectiveness. A hypothetical example serves as an illustration. In previous assessments, the lack of adequate scientific methods or data has opened the assessment process up to science-based criticism -- in other words, the assessment lacked scientific credibility. In the case of POPs, one might imagine a hypothetical report that used incorrect production data or faulty emission estimates as a basis for concluding which chemicals should be addressed in a protocol. Because these emissions estimates were not scientifically credible, negotiators therefore might spend their time arguing the

merits of the emissions estimates, a process which at best would delay decisions on substances and at worst might derail the negotiations. Therefore, this is an example of a pathway through which a pitfall in the assessment process might influence effectiveness, where effectiveness is taken as the progress of the negotiations.

2.5. Learning

After identifying those elements that might influence effectiveness, how can other processes learn better lessons from them? The literature on policy evaluation and social learning provides a background for this question. In their book *Thinking in Time*, Richard Neustadt and Ernest May examine how history is and should be used in governmental decisionmaking. They caution that the "usual" practice of decisionmakers is often marked by "overdependence on fuzzy analogies" (Neustadt and May 1986). Policies are often made by analogizing or drawing lessons either from history or from the experiences of other issues or policy arenas. The Social Learning Group (forthcoming) has looked broadly at the evolution of management in human interactions with global environmental change.

Rose (1991) has classified ways in which policymakers may draw lessons from others' experiences. Though Rose specifically addresses the problem of transferring policy programs across national boundaries, his conclusions about lesson-drawing are relevant to all policies, and are of particular interest in looking at the setup of assessment processes. Rose sets out several "alternative ways of drawing a lesson," including copying (adopting a program without much change), emulation (adjusting an existing program for particular circumstances), hybridization (combining elements of two programs), synthesis (combining elements of three or more programs), and inspiration (using others' programs as stimulus for developing a unique program). According to Rose, a final step in lesson-drawing is prospective evaluation: evaluating the likelihood of successful transfer. Rose writes:

> Prospective evaluation combines empirical evidence about how and why a programme works in country X, with hypotheses about its likely success or failure in country Y. An element of speculation is inevitable, but it is not unbounded, as in purely speculative prescriptions. Prospective evaluation is constrained, because it compares observable characteristics of an effective programme in one country with observable conditions in another; speculation is confined to reckoning the future effect of changes in the latter (Rose 1991).

The comparison of assessment processes in the POPs protocol to those in other LRTAP protocols, which will be the focus of sections 3 and 4, is an effort to provide evidence for better prospective evaluation in the arena of transnational science-policy assessments. Looking at how LRTAP's processes for incorporating science into policy were adapted to the POPs negotiation, and analyzing the effectiveness of these processes, will provide an empirical basis for evaluations of how these same processes might transfer to other transboundary issues. The inevitable speculation, therefore, might become more informed.

2.6. Conclusion: A Model for Analysis

This paper will measure the effectiveness of the scientific assessment process in three of LRTAP's protocols by analyzing the extent to which science facilitated or stalled policy progress. Facilitating or stalling progress will be defined with reference to the particular framework of criteria that indicate the ways in which science might influence the policy process. Ways in which science can facilitate policy progress include *establishing a basis for further action, providing evidence to justify decisionmaking*, and *focusing and channeling debate*. Ways in which science can stall policy progress include *promoting excessive debate over uncertainty, failing to provide credible or relevant evidence*, and *shifting debate to methodological controversies*. The scientific advice process in negotiations of LRTAP protocols will be assessed by comparing the instances in which science facilitates policy progress with those which stalled progress, with reference to the characterization summarized in Table 2.1. Once the relative degrees of effectiveness of assessment processes in LRTAP protocols have been established, the qualities of the assessment process that might influence effectiveness will be examined. A broad view of determinants of effectiveness will be employed, considering those variables that fall into the general categories of *context, content*, and *process*. Such influences might include issue- or forum-specific variables, as well as particular design choices and procedures. The causal linkage between independent variables of context, content, and process and the outcome of effectiveness will be analyzed with reference to the idea that a particular variable might facilitate avoidance of a common pitfall of the negotiating process. These pitfalls might be avoided through a mechanism whereby variables of context, content, or process influence an assessment's *credibility* (either scientific or political) or *relevance* to the issue, and thereby influence assessment effectiveness (the pathways by which these variables will be analyzed are outlined in Table 2.2). Credibility or relevance in turn influence effectiveness by facilitating or stalling issue progress. Finally, the results of this examination will be analyzed for their application to the problem of prospective evaluation, with reference to the boundaries of such evaluation. Examining policy learning in this way, with reference to these cases, leads to hypotheses that might guide policymakers and analysts of assessment issues in applying the lessons of LRTAP to other international environmental issues.

3. Is LRTAP Assessment Effective?

The Convention on Long-Range Transboundary Air Pollution is often cited as a model of effective science-policy collaboration. LRTAP has developed a large scientific infrastructure for monitoring and evaluation, and has incorporated an increasing role for scientific assessment and information in negotiations. Levy (1995) notes, "The LRTAP process integrated knowledge-building exercises artfully with the task of negotiating international regulations." Participants in LRTAP negotiating processes often cite science as a strong basis for and one of the successes of their work.[2] One delegate said of LRTAP, "Over the 20 years that the convention has existed, it has built up quite a network and support system to develop good scientific work. There's the EMEP process, and the working group on effects, and the...integrated assessment modeling done through IIASA, which has matured over that period of time."[3]

Given this propensity for participants in, and analysts of, the LRTAP process to consider its use of science effective, this section seeks to examine these assumptions, determine the extent and dimensions of this effectiveness, and analyze whether different protocol negotiations were more effective in this use than others. In doing this, it will utilize the progressive conception of effectiveness developed in section 2, with specific reference to the general characterization of ways in which science might facilitate or stall negotiations. This section will examine the degree to which scientific assessment was effective in moving the policy process forward in three protocols to the LRTAP convention. The main focus of this analysis will be the 1998 Aarhus Protocol on Persistent Organic Pollutants (POPs); the POPs protocol assessment process will be compared with assessment processes in the 1985 and 1994 sulfur protocols. Considering the relative areas of effectiveness in the assessment processes for these three LRTAP protocols will allow comparisons to be made about the variables which might influence the dimensions of this effectiveness across these different issue areas. As noted in section 2, effectiveness will be considered from the point of view of those involved in negotiations of LRTAP protocols, and measured with respect to the use of assessment in influencing policy progress.

Because the negotiation of the POPs protocol shared with other LRTAP protocols the same institutional context and many similar procedures and norms, the first question to ask in an examination of the transferability of principles for science-policy assessment is whether there is any difference in the character of effectiveness in this case. Put another way, did the differences between the assessment process in POPs and other LRTAP protocols result in any differential among them in the extent and characteristics of effectiveness?

It is difficult to draw a clear parallel between the type of protocol that resulted in the POPs case and any one of the previous LRTAP protocols. Within the LRTAP convention, participants refer to "first-generation" and "second-generation" protocols in describing the level of action on a particular substance. "First-generation" protocols in the LRTAP context are based on best-technology approaches to regulation and flat-rate emissions reductions, whereas "second-generation" protocols (the 1994 sulfur protocol, and the multi-pollutant, multi-effect protocol currently being negotiated) are negotiated and implemented using effects-based approaches. Because the 1998 protocol represents the first addressing of POPs under the LRTAP convention, it can be considered a "first-generation" protocol. However, because the POPs protocol is the most recently negotiated protocol, its scientific process and institutional context were significantly more advanced than some of the earlier "first-generation" protocols negotiated under the LRTAP convention. LRTAP's Working Group on Strategies chairman Lars Bjorkbom (1997) writes that the negotiations of the POPs protocol, as well as those of the concurrently negotiated protocol on heavy metals, "could be characterized as a mix of technique and effects-based approaches." The POPs process benefited from many of the experiences and lessons of negotiating "second-generation" protocols. For these reasons, comparing effectiveness in the POPs negotiation's science-policy process only to a first-generation protocol or to a second-generation protocol would be an insufficient parallel. Therefore, here effectiveness in the assessment process in negotiating the POPs protocol process will be compared to effectiveness in both the 1985 and 1994 sulfur protocols, a first- and a second-generation protocol.

3.1. Effectiveness in the 1985 Sulfur Protocol

In the early years of LRTAP negotiations, the convention and subsequent protocols were almost completely political documents. Science played a role, and indeed the framework convention itself was an agreement on scientific cooperation and information exchange (Bjorkbom 1997). However, the actual amount of scientific information incorporated into decisionmaking on early protocols, particularly the first sulfur protocol, was small. A senior delegate who was involved in these negotiations noted, "I would say that the internalization of science as an important component in development of an agreement [has] mostly...become manifest during this decade."[4] Another said of the same issue, "When this convention started, there was always a desire to make it scientifically-based and scientifically sound, but in the early stages, the early protocols, there was very little science, and it was really just as much as saying we ought to get a 30 percent reduction."[5]

The lack of a scientific basis for particular decisions does not mean that science did not have an influence on the policy process. That there was little science does not necessarily mean that the scientific assessment process was ineffective. For exactly this reason, the formulation of effectiveness as progressiveness is a helpful one in analyzing how scientific information fed into the development of policy. In a progressive formulation, fully mature science is not a necessary precondition for science facilitating or stalling policy development. This, indeed, is a separate question. Therefore, in the case of the first sulfur protocol, the information that did go into the process is most helpfully analyzed by examining its effects on the policy process.

This concept of effectiveness does not presuppose that moving the policy process forward necessitates a decision to take action on a perceived environmental threat. Moving the policy process forward from agenda-setting to decisionmaking does not necessarily mean that the decision taken will be to regulate substances. For example, under this framework, a scientific advice process that helped move a policy process towards a decision to cut emissions of a given pollutant would be as effective as an assessment process that led to a decision that the same pollutant did not warrant international action. However, though such a situation is not unimaginable, it is unlikely to occur within the framework of the LRTAP convention. This is because in order for an issue to get onto LRTAP's agenda, a party to the convention must invest a great deal of resources and political capital into the argument that a substance should be regulated, and it is unlikely that an international assessment process would lead that party to agree to decide not to address that substance. This scenario, coupled with the *modus operandi* of LRTAP policymaking as consensus-based, leads to the conclusion that in most cases, lack of action on a substance would signal the breakdown of the policy process and perhaps an ineffective assessment process, rather than a consensus decision to forego further negotiation.

Science played a role in the first sulfur protocol to the LRTAP convention in three major ways: in agenda-setting, in the identification of sources, and in the ways uncertainty was handled by negotiators. In two of these, science helped to move the policy process forward, and in the other, it was used to try to stall the process. The role of science in the agenda-setting process served to establish a basis for further action on acidifying substances. Identification of sources of sulfur provided evidence to justify decisionmaking. On the other hand, certain countries used science to promote excessive debate over uncertainty in the later stages of the negotiations.

First, science played an important role in facilitating the placing of sulfur on the international agenda. This was an example of science establishing a basis for further action, from which the policy process could move forward. In the assessment of Working Group on Strategies chair Bjorkbom: "Science certainly helped to bring acidification to the attention of public opinion, at least in the West" (1997). Though the initial impetus for the LRTAP convention came from the political cooperation of the Helsinki Conference on Security and Cooperation in Europe (Levy 1993), there was also a strong basis of scientific data showing that acidifying pollution was a long-range transboundary problem. Particularly important in the process for gaining scientific acceptance of a problem of atmospheric pollution were the role of the OECD and the 1972 Stockholm environmental conference.[6] "When this convention came about, certainly it was scientific findings that were in the bottom," said one delegate. "It was a very long fight to get acceptance that emissions...had a spread that went hundreds and perhaps even thousands of miles, and in the European context at least that meant it was transboundary."[7] Getting consensus on science was a crucial first step before the sulfur protocol could even get onto the international agenda in the LRTAP context. One of the forums in which acidification science played such a role was the 1982 Stockholm Conference on Acidification of the Environment, convened by Sweden. The Stockholm conference was essentially two meetings, one of scientific and technical experts, the other a ministerial meeting (McCormick 1997). At that meeting, the assembled experts concluded that evidence of a problem was sufficient for action, that action would reduce environmental damage, and that cost-effective and feasible emissions control technologies existed (Park 1987). The influence of expertise at these conferences helped to move along the process towards action on the issue of sulfur. In this way, scientific input played a role in helping to secure the issue of transboundary acidification as an international problem, thereby providing a solid foundation from which further negotiations could build.

Second, science influenced the policy process leading up to the negotiations of the first sulfur protocol by identifying links between sources and effects. Establishing a linkage between receptor and emitter was important in defining acid as a problem.[8] This was an example of science being used to provide evidence to justify decisionmaking. One delegate emphasized this function of science in the case of LRTAP's sulfur protocol: "The science came in for the sulfur not so much to identify the problem but to identify the culprits, and the science came in acidification to prove that it was in a sense the UK and Poland that were sending their dirt to Sweden."[9] The influence of science facilitated the provision of evidence that the acidification problem was causing particular problems due to excessive pollutant emissions from specific sources. This evidence was necessary in order for the decision to go ahead with negotiations on specific pollutant protocols to be accepted.

Third, scientific information influenced the progress of the negotiations when parties used uncertainty to stall negotiating progress. The decision to choose a 30 percent reduction was not based on science; some parties used this lack of science as justification for arguing against further action in negotiations. This was an instance in which scientific information was used to promote excessive debate over uncertainty. According to one participant, "Those who didn't want to do anything were citing an unsatisfactory scientific base for such a thing, and of course in a sense they were right, but the function was to simply start the ball along."[10] Bjorkbom (1997) notes that the U.S. and the U.K. cited inconclusive scientific evidence as reason for not

joining the so-called "30-percent club" of countries that had agreed to cut sulfur emissions by 30 percent. These countries used scientific uncertainty to promote disagreement, which served to stall negotiations. This debate was excessive, or unwarranted, because it focused on an element of uncertainty which did not have particular relevance to the decision to cut sulfur emissions by 30 percent, given that this decision was a political one.

Overall, in the case of the first sulfur protocol, what science did inform the process helped to establish sulfur as an issue on the international agenda, identify emitters, but also stall progress. The scientific assessment process clearly exhibited effectiveness in getting the issue onto the agenda; however, the influence of science in later stages, which were dominated by politics, was a stalling force. The ways in which scientific assessment appeared most effective in the case of the first sulfur protocol were in its setting a basis for further action. In this case, though there was little science, it seemed to work.

3.2. Effectiveness in the 1994 Sulfur Protocol

Analyzing the role of science in the second sulfur protocol offers much more data upon which to base measures of effectiveness. The second sulfur protocol, signed in 1994, was based on the concept of "critical loads" and an effects-based approach to management -- that is, emissions reductions are based on cuts relative to thresholds for the effects of environmental pollutants (McCormick 1998). Both the science of acidification and the institutions of scientific assessment had developed much since the experience of negotiating the first sulfur protocol, and the decision to base further negotiations on the concept of "critical loads" represented a substantial way in which policymakers used scientific assessments in negotiations. The acceptance of the critical loads concept, at least by European parties to the Convention, was the product of a process that relied on both substantial assessment activity and negotiation. In addition, in order to facilitate decisionmaking based on critical loads, negotiators made use of assessment tools such as integrated assessment models, the preeminent one being the RAINS (Regional Acidification Information and Simulation) model developed at the International Institute for Applied Systems Analysis (IIASA) (Hordijk 1991).

In the negotiations of the second sulfur protocol, scientific assessment had several influences on the process of negotiation. Acceptance of the critical loads approach shifted debate from controversies over basic science into the application of science, moving the policy process forward from agenda-setting to policy decisionmaking. The use of integrated assessment modeling also contributed strongly to this policy progress. In these ways, science facilitated issue progress by focusing and channeling debate, or instituting a common language of evaluation. Results of emissions assessments and analyses of deposition and environmental damage provided evidence to justify decisionmaking. On the other hand, uncertainties and modeling were again used as delaying tactics in negotiations, in this case by shifting debate to methodological controversies rather than substantive issue disagreements.

The critical loads approach represented an effort to incorporate assessment of the impacts of pollutants into decisionmaking on protocols. The idea of critical loads grew out of scientific work by impacted countries, particularly Sweden, and commitments to base further protocols on critical loads were elements of the 1988 NOx protocol and the 1991 VOC protocol (Levy *et al.*).

The 1994 sulfur protocol aims to achieve a "60 percent gap closure" between sulfur deposition and critical loads in Europe (Thommessen 1997).

The idea of critical loads served to push debate on effects-based controls on acidifying compounds to the policymaking realm. Levy *et al.* (forthcoming), in their analysis of critical loads as a policy goal, argue that the scientific consensus after 1988 on critical loads methodology "resonated with and reinforced developments in the international policy realm." They conclude, "judged by the criteria of whether or not progressive change in the broader management of acid rain came about, the critical loads approach was clearly a success." One of the reasons for this success was the broad acceptance of critical loads as a concept, at least among the European LRTAP parties. One delegate credited this acceptance to the scientific nature of the critical loads concept, and noted that it was this acceptance that formed the basis for the negotiations.[11] Another negotiator noted that science surrounding the critical loads concept structured what the process was trying to accomplish, designed the analysis, and then led to the traditional type of "political" decisionmaking on action.[12] Indeed, once agreement was reached on the "critical loads" methodology, this underlying assessment framework was in effect off the negotiating table. What was on the table, however, was the degree to which parties would reduce emissions relative to critical loads -- termed critical targets. This was seen as a political debate, but it built upon the underlying concept of critical loads to which at least European parties had agreed. The concept of critical levels, coupled with the negotiation of critical targets, allowed participants to agree to a common method of evaluation without yielding negotiating flexibility. In this way, the science behind "critical loads" allowed negotiators to move towards decisionmaking. The division between "scientific" and "political" decisionmaking here is problematic here because the "critical load" concept itself, completely apart from debate over critical levels, was indeed a product of an assessment process that was not purely scientific. Indeed, the decision to set critical loads to protect the most sensitive five percent of ecosystems could be considered a policy decision. However, this process was structured in such a way that made it credible to participants, who considered the information coming out of such an assessment process as authoritative. A participant in the scientific work credited some of the success of the underlying "critical load" concept to the setting of one number as a parameter by which negotiators could measure many different scientific consequences: without this development, he argued, it would have been difficult to derive a sensible protocol from science.[13] A relative degree of consensus emerged among Europeans on a "number" that was a product of a science-policy negotiation; this development had the effect of channeling debate to the concept of critical levels, by taking certain questions off of the negotiating table. This channeling of debate is an example of a way in which assessment was effective in negotiations of the second sulfur protocol.

In negotiations on the second sulfur protocol, integrated assessment models established a common method of evaluating options, costs, and effects. The use of such modeling provided scenarios by which parties evaluated the costs of remedial action on sulfur, and measured the effects of such action on levels of sulfur relative to critical loads. Negotiators used models to predict the effects of various levels of regulatory action on the level of sulfur in the environment. Negotiators viewed the results of the models as extremely credible, and this helped to move discussion towards what was to be done.

In some cases, according to one of the scientific participants, some parties employed integrated assessment modeling in order to delay decisions on issues. However, it is clear that both the critical loads concept and the scientific input from integrated assessment modeling helped to shift debate to decisionmaking based on commonly accepted principles. In these ways, the use of science in the second sulfur protocol was effective.

3.3. Effectiveness in the 1998 POPs Protocol

The POPs protocol represented a new and different breed of LRTAP science and politics. Not only were POPs very different types of compounds from sulfur, nitrogen, or even volatile organics, the type of science and scientific assessment that informed the POPs negotiations was also distinct. Though a number of delegates seem to agree that the assessment processes that informed the POPs and sulfur negotiations were very different, they differ greatly in the reasons they give for these differences. Some delegates mentioned in interviews that the POPs assessment process was different because the "state of the science" -- or the extent of scientific knowledge about the substances -- was less developed in the POPs case.[14] One European delegate's opinion was that a lot of science went into the process of negotiating the POPs protocol, but not as much as in the acidification case: "You can't compare it completely because in acidification you're working on it for 20 years now and the convention started because we want to attack acidification, and so we have acquired a lot of knowledge about that...when we started on POPs, this is only 5 or 6 years ago, and we had there to start from scratch."[15] The second sulfur protocol built on the knowledge gained by negotiating the first; even in negotiations of the first sulfur protocol, work on acidification in related international contexts had been ongoing for over ten years. Scientific knowledge on POPs, however, had not been so collected. A member of the initial POPs assessment task force noted that the acidification protocols involved more complicated, in-depth scientific work, whereas the scientific resources put into POPs were "much more minor."[16] Another delegate characterized the POPs debate as more of a technical debate with policy implications, where there was disagreement on the technical side, whereas in the sulfur protocol, "everyone agreed what the problem was. The problem was to raise the profile of the scientific information to convince the policymakers."[17] The same delegate also cited the types of effects seen in the POPs case, primarily remote health effects that were not so identifiable as forest and lake impacts of sulfur, as a reason why distinct scientific procedures were necessary. Other negotiators mentioned the fact that many POPs are commercially-produced chemicals rather than unwanted byproducts as a reason why the assessment processes differed.[18]

It is useful at this point briefly to outline the path that the assessment process took in negotiations of the POPs protocol, in order to contrast this process with assessment process in earlier LRTAP protocols. LRTAP's addressing of the issue of persistent organic pollutants began in 1989, when the Convention's Executive Body charged a group of experts to prepare a discussion paper on POPs. A Task Force on POPs, set up by the Executive Body, met four times between 1991 and 1994, and produced a substantiation report -- an assessment report outlining the state of scientific knowledge on POPs emissions, transport, impacts, and abatement techniques. An *ad hoc* preparatory working group on POPs met four times during the next two years, and drafted a composite negotiating text for a POPs protocol (Nordberg 1998). Formal negotiations began in the Working Group on Strategies in January 1997, and the POPs protocol was opened for

signature in June 1998. The main differences between the process of scientific assessment in the POPs case and in the sulfur cases were the emphasis on basic science, and the procedure by which scientific assessment work occurred in the context of the convention before negotiations on a protocol.

Though not all participants agreed that the scientific assessment process in the POPs case could legitimately be compared to such processes in other LRTAP negotiations, participants were generally positive about what they viewed as the effectiveness of the science process. A North American delegate's assessment of the POPs protocol was that "in a very real sense science was the basis, and proved to us the need for us to go out and have a protocol for this."[19] A leader in the early scientific work addressed effectiveness by gesturing to the impact and credibility of the task force report: "Most of the conclusions we made and the criteria, etc., were accepted by a broader public, basically because it was founded on the scientific background."[20] One senior U.S. delegate characterized the role for science as "an uphill battle"; however, he was primarily referring to the difficulties encountered in the late stages of negotiations.[21]

A more thorough assessment of the effectiveness of the scientific assessment process again looks at the impact that scientific knowledge made on moving the policy process forward. In the POPs case, there are several examples of scientific knowledge having such an influence on the policy process. Among these are the role of science in getting POPs onto the international agenda, the influence of the task force report on moving the process towards decisionmaking, the role of basic consensus on less controversial science in propelling negotiators towards agreement, and the impact of disagreements over more controversial science, particularly in substance selection, as a delaying tactic and a flash point in negotiations. In the first two examples, science facilitated issue progress by establishing a basis for further action; scientific assessments at a key point in the negotiations also may have provided a justification for decisionmaking on substance inclusion. Disagreements stalled issue progress in many ways, which fell into all three of the broad categories outlined in section 2: promoting excessive debate over uncertainty, failing to provide credible and relevant evidence, and shifting debate to methodological controversies.

Science first had an influence on the process of negotiating the LRTAP POPs protocol in an early stage of the policy process -- in getting the issue of POPs onto the international agenda. In the early years of concern about POPs in the LRTAP context, parties explicitly looked upon science as providing a basis for further action. The international issue of persistent organic pollutants, and the beginning of negotiations of the LRTAP POPs protocol, grew out of driving forces of both science and policy. There was a wealth of scientific evidence growing on the POPs issue, but also a strong political imperative for action. The pushing of POPs onto the LRTAP agenda came mainly from Canada and Sweden. Sweden, historically a country promoting environmental action in LRTAP, was affected by POPs because of the substances' tendency to accumulate in the arctic. Canada, in addition to arctic impacts, was experiencing in domestic politics a heightened sensitivity to the concerns of its northern Inuit populations, who were highly impacted by POPs.[22] A Canadian delegate cited science as the basis that proved to Canada the need to have a protocol; the Canadian government's mandate for negotiators was that the protocol had to be based on solid science.[23] Another delegate mentioned the strong underpinning of technical work that "helped get

all countries up to the same level of knowledge" and understanding of the POPs problem, because the nature of the problem was so different from LRTAP's previous air pollution issues.[24]

The work of the Task Force explicitly set out to provide a scientific basis from which further work could proceed. The designated experts meeting that was held immediately prior to the first meeting of the Task Force (March, 1991 in Solna, Sweden) set its objective as establishing "a consensus amongst participating countries on principal long-range transport processes; geographic patterns of occurrence, and on established and potential effects to biota and to human health of persistent organic contaminants."[25] In the initial draft work program for the Task Force, the first of six priorities was to "establish a common basis for the work."[26] A senior task force participant, asked about how successful the process for incorporating expert advice into the POPs negotiations was in facilitating progress, cited the task force work as crucial:

> From the beginning when we started in 1990, I think we were quite aware that we really had to make a good assessment of the knowledge, the science. Without that there would be no protocol. So from the beginning we said, let's try to make a good task force report that later on the negotiation could be based on....it took four years to make that task force report! But I think that report later on was accepted, and not very much questioned.[27]

The initial assessment prepared by the designated experts at Solna, and adopted at the first task force meeting, was a scientifically-based paper that addressed sources, transport, deposition, ecosystem uptake, ecosystem health effects, data trends, and human health for organochlorine compounds (one family of POPs substances). It concluded that "significant long-range transport through the atmosphere is important."[28] The work of the Task Force, over its four meetings from 1991 to 1994, culminated in the production of a State of Knowledge Report, which substantiated the state-of-the-art science on aspects of the POPs problem (UNECE 1994a). The Task Force report formed the basis for the recommendation that further steps be taken by establishing an *ad hoc* Preparatory Working Group on POPs. At the twelfth session of the LRTAP Executive Body, at which the *ad hoc* Preparatory Working Group was established, several delegations expressed satisfaction with the executive summary of the state-of-knowledge report (UNECE 1994b).

The establishment of a basis of agreement among delegations -- that a core group of POPs were transboundary air pollutants that should be addressed as part of the LRTAP convention -- became especially important as negotiations progressed on more complicated and uncertain substances. A North American delegate involved in the initial work distinguished the "core of concern" -- the principles of persistence, long-range transport, and effects on the arctic environment -- as material which was well-founded in good scientific literature about the nature of chemicals and environmental problems. The "core," or basis, represented both the scientific background information that supported POPs as a transboundary problem, and the set of a few substances that it was agreed were in this category. The North American delegate contrasted this "core" with the more uncertain substances addressed later in protocol negotiations where the science was weaker; he felt that the "core" science kept the issue on the table and forced agreement, because if negotiators couldn't agree where the lines were between substances to address or not, they wouldn't do anything about the core.[29]

The initial assessment reports, and early substantiation work on POPs science, served to facilitate decision on establishing basic consensus, move the process towards a negotiation phase, and ultimately, form a common core of science that pushed parties to complete negotiations. The main conclusions of this scientific work were little-criticized in the negotiating process. Indeed, the task force work was one of the most prevalent examples of successful scientific assessment cited by participants in interviews.

In contrast, some of the key instances in which scientific advice served to stall the negotiations occurred in selecting substances for inclusion in the protocol. A major part of negotiating the protocol was deciding which substances such a protocol would cover, and how many there would be.[30] Some countries, such as Sweden, were advocating that a large list of POP substances be included; the United States, on the other hand, favored a more limited list.[31] In the selection of substances, scientific assessment facilitated debate by providing a common language for evaluation through criteria. Science stalled the policy process in major ways when countries used uncertainties and lack of data to prevent further policy development. However, the use of science may have helped solve the problems it got itself into, by parties' use of science as a justification for taking a particular position.

The initial list of substances selected for inclusion in the POPs protocol was identified by a screening process set up by the Task Force and the Preparatory Working Group. The Task Force had identified a list of 105 candidate substances compiled from lists of chemicals addressed by other conventions, particularly the Helsinki Commission (HELCOM) and the Paris Commission (PARCOM). The pesticides DDT and Mirex were added for consideration, bringing the total number of candidate substances to 107. The Preparatory Working Group compared several methodologies for evaluating and ranking these substances, all of which took into account a substance's potential for long-range transport, bioaccumulation, persistence, and toxicity. The methodology eventually adopted by the Preparatory Working Group, at its third session, was a three-stage process. In the first stage, substances were screened for long-range atmospheric transport potential, including persistence. The second stage scored and ranked substances based on their toxicity and their bioaccumulation potential. The third stage was a detailed assessment of long-range transport risks. The Preparatory Working Group applied this procedure to the list of 107 substances; it presented 14 substances to the Working Group on Strategies for inclusion on the initial list, and recommended further evaluation and sought policy guidance for six others.[32] Other substances were either judged not to warrant action, or were not recommended for action due to lack of sufficient data.

According to a summary paper presented to the 3rd session of the Preparatory Working Group on criteria and procedures, the different methodologies considered produced "good overall agreement on the selected priority substances, but leave a few substances in a grey area of uncertainty."[33] The selection of substances with reference to a set of criteria determined by an assessment process was an example of science providing a common language for evaluation, and thereby facilitating policy progress. Criteria channeled debate in this way, and provided a structure for further negotiations on these substances. Parties agreed that substances that fulfilled particular criteria should likely be included. Parties differed on the extent to which they viewed these criteria as determinative (and, to some extent, on the specific cutoff points); however, they

accepted the concept of criteria to the extent that substances proposed for inclusion were all evaluated on this same basis. The concept of criteria was a product of an assessment process in the Task Force and Preparatory Working Group, a process that combined elements one might consider "political" as well as "scientific." Through a process of negotiation in the Preparatory Working Group context, criteria became part of a procedure by which substances could be evaluated; parties agreed to the fundamental standards set out in this procedure. Criteria, therefore, provided a framework by which the relevance of different aspects of scientific data on these substances could be considered. The relative agreement on at least the concept of criteria, therefore, was a way in which early assessment work was effective in channeling debate.

Had criteria not been instituted as the basis for initial substance selection, one might expect a drastically different sort of debate over which substances would be included, likely one which would have been more controversial. For example, without the attempt to develop agreed-upon criteria, there would have been no accepted framework by which scientific information on substances could be evaluated together. Evaluating a substance that is highly bioaccumulative and moderately persistent against one that is highly persistent and moderately bioaccumulative, for example, to determine which poses greater long-range risk, might have degenerated into an excessive discussion of scientific uncertainties. In such a case, policymakers would have been putting a question to science that it could not answer without policy guidance; this would have stalled the negotiating process by highlighting uncertainties that lacked direct relevance to the issue at hand. With the establishment of criteria, there was a clear framework by which substances were ranked and ordered; though this ranking was certainly not purely "scientific," it was accepted by parties and allowed debate to move forward. In addition, in a process without criteria, the inclusion of every substance would have been more a reflection of country priorities, and negotiation of every substance would be on the table. Acceptance or rejection of a substance would be to a greater extent a difficult political tradeoff, without the justification that science could have, and indeed did provide in the particular case of the substance pentachlorophenol, described below.

The setting of particular criteria numbers and a procedure for adding additional POP substances after ratification of the protocol became an area of much controversy as well, and became to some extent a methodological dispute that delayed negotiations. The POPs protocol was designed to be a dynamic instrument, so that further substances could be regulated in the future without the negotiation of an entirely new protocol. The term "criteria" as it applied to additional substances refers to a slightly different process. The process by which substances were ranked and selected for initial inclusion, and the process set out for selection of additional substances, were two distinct but interconnected examples of "criteria-setting." The procedure for adding new substances to the POPs protocol, set out in an Executive Body decision, uses criteria as guidance for evaluating proposed additional substances. Questions about whether criteria should be used in additional substance evaluation as "bright lines" of distinction or as "guidance," as well as disagreements over what specific numbers should be set, were particular points of contention in the negotiations.[34] The channeling of debate, therefore, was not without its pitfalls. However, in general, the agreement to conduct the debate on the basis of criteria principles did serve to focus debate.

The acceptance of the concept of selection criteria, however, did not prevent controversy over substances from stalling negotiations over inclusion. In particular, two of the six substances recommended for further assessment, lindane and short-chain chlorinated paraffins, became the

subject of further controversy.[35] In these particular cases, the scientific assessment of such substances became the topic of negotiation. The negotiation did become, as one delegate stated, a "technical debate with policy implications." This served to stall negotiating progress.

The most illuminating example of the effect that scientific assessment had on influencing the progress of the negotiations occurred in the case of one of the fourteen substances recommended for inclusion by the Preparatory Working Group: pentachlorophenol. Every delegate interviewed about the role that scientific assessment played in the progress of POPs protocol negotiations mentioned the debates over pentachlorophenol as an example of science influencing policy. Pentachlorophenol, a wood preservative, is a substance widely regulated in Europe, and to several European countries, it was clearly a substance that should have been included in the protocol.[36] Late in the negotiations of the protocol, in mid-1997, the United States, prompted by new data from industry, reexamined the initial data that had prompted pentachlorophenol's inclusion.[37] The U.S. believed that the new data indicated that pentachlorophenol did not satisfy the criteria for inclusion.[38] At a meeting of the Working Group on Strategies in September, 1997, technical experts from the U.S. Environmental Protection Agency and the Chemical Manufacturers Association presented the new industry data on pentachlorophenol, and their interpretation that this data did not support its inclusion on the protocol.

This presentation stood out in the minds of negotiators because it was one of the few instances many could remember of basic science being the topic of discussion in the forum of the Working Group on Strategies, the negotiating arm of the LRTAP Convention. A European delegate spoke of "the big push that the US produced massive amounts of information to try to convince all of us that pentachlorophenol was not a POP." He added, "That was essentially very much argued on scientific terms by having the industry moving around large amounts of scientific papers, and flooding our desks with results from scientific papers who are showing that it's the case on a scientific basis."[39]

The industry science presented by the U.S. was greeted with skepticism by Europeans. A senior member of the U.S. delegation observed that when the U.S. raised questions about pentachlorophenol, basically all European countries "laughed at us," since the substance was so heavily regulated in Europe.[40] Asked how credible he found the information presented by the U.S., a senior delegate from Sweden said, "We had some problems with that. I mean, our sincere opinion was that this substance should be in the protocol."[41] He noted, however, that the U.S. had indicated that it would not sign the protocol if pentachlorophenol was included; the inclusion of the U.S. in the agreement was seen as critical by certain key players in the negotiations, including Sweden.[42]

A U.S. delegate believed that the science convinced some of the countries of their position, but also that the science played a key role as a justification for a politically expedient decision: "Although not everybody agreed with our interpretation, they could see that there was a basis for our interpretation, and when that was then coupled with the political reality that they were faced with the U.S. not signing the protocol if they insisted on [pentachlorophenol] being there, it was a way in which they could accept our demand, without it being just a matter of caving in to the

U.S." He added, "It allowed them a way...to grumpily accept it. So, in that sense, having that kind of information and expert advice facilitated a political decisionmaking process."[43]

The outcome of this debate was that pentachlorophenol was left off the initial list of substances regulated under the POPs protocol. Science, therefore, provided cover for a political decisionmaking process. Because decisions taken on the basis of science were seen as more authoritative and credible, any science -- even questionable science -- could prove useful. In contrast, one could imagine a scenario in which U.S. demands that pentachlorophenol not be included were not made in scientific language but as a purely political ultimatum. According to the U.S. delegate, this would have made the decision by other countries to remove pentachlorophenol from the list a much more controversial one. The process, therefore, would have been delayed.

A key factor in negotiations that led to this agreement not to address pentachlorophenol was that the POPs protocol was envisioned and designed as a dynamic instrument in the context of the LRTAP convention. It was understood among negotiators that a substance left off the protocol in its first incarnation could later be added via a negotiated procedure relying on scientific criteria and political decisionmaking; the decision to set up this protocol as a dynamic one was made rather early in the process. For this reason, countries favoring pentachlorophenol's inclusion could agree to put off decision on the substance until further scientific work could be performed and more evidence could be employed, without agreeing that pentachlorophenol would never be regulated internationally. In fact, the issue of pentachlorophenol was addressed in the section of the protocol dealing with research, development, and monitoring. Parties agreed to encourage research on "levels of persistent organic pollutants generated during the life cycle of timber treated with pentachlorophenol."[44] The inclusion of pentachlorophenol here in the research section was an additional way that science helped to encourage countries' agreement. The dynamic structure of the protocol facilitated the use of science as "cover" for a political decision, and allowed the less authoritative science of U.S. industry "grumpily" to be accepted. The influence of this dynamic structure will be explored further in section 4.

The debate over pentachlorophenol is a particularly good example of how science was used in the process of negotiating the POPs protocol because scientific information played such a major role at a crucial point in negotiations. Debates over the inclusion of substances were carried out in scientific terms, because the agreement on the concept of criteria had established this as a particular accepted language. The establishment of criteria as a concept for evaluation facilitated the process of substance selection by establishing a basis of assessment on which parties could agree; however, it stalled the process by shifting policy debate onto technical terms, which hurt the credibility of scientific evidence presented. A U.S. delegate noted in discussing substance selection, "The science...got heavily weighted towards why did we want to include or not include."[45] On the other hand, the conducting of debate on scientific terms provided for the use of science as a justification mechanism for making difficult political decisions.

In the case of the POPs protocol, participants' observations that use of science was effective tend to be supported by examination of the progressivity of the assessment process. The assessments establishing the initial scientific basis for work provided a strong push towards further agreement. Scientific debates around the issue of substance selection and criteria later stalled the process, but the use of criteria overall played a substantial role in facilitating agreement,

particularly in establishing a common basis for evaluation and avoiding the conducting of substance selection on political terms. Where science stalled the process, for example in the case of pentachlorophenol, science was also used to overcome these difficulties, particularly by providing justification by which agreement could be facilitated.

3.4. Comparing Effectiveness in POPs and Sulfur Protocols

All three of the protocols to the LRTAP convention examined above exhibit a degree of effectiveness in their use of scientific assessment. The specific types of science used in each case were very different: from acidification and transport research in the initial sulfur protocol, to integrated assessment modeling in the second sulfur protocol, to toxicology and criteria-setting in the case of POPs. However, science was used in the policy process for the same sorts of purposes. In each protocol, the uses of science fell into one or more the broad categories set out in section 2 of ways in which science can facilitate or stall policy progress. Therefore, the dimensions and degrees of effectiveness in these protocols can be compared.

In the first sulfur protocol, little science influenced negotiations directly; however, early acidification assessments served to form a scientific core of concern from which negotiations could proceed. The second sulfur protocol made use of the concepts of critical loads and integrated assessment modeling to focus and channel debate. In the POPs protocol, negotiators repeatedly looked to science for help in overcoming policy difficulties, solving disagreements, and facilitating agreement among parties. In the POPs case, the establishment of criteria and the use of science in choosing substances stands out as effective as well. Those negotiating the POPs protocol were more explicit in their acknowledgments of the uncertainties of science in that case than in negotiations of the two sulfur protocols, and they used science creatively to sidestep difficulties in the policy process, as is clear from the pentachlorophenol example.

In the three protocols examined, several common dimensions of assessment effectiveness emerge. In all three protocols examined, assessment processes provided a common core of scientific agreement upon which negotiators could base further action. The second sulfur and POPs protocol negotiating processes succeeded in using assessment to channel debate, in the case of critical loads and criteria-setting. Evidence-provision was an area of effectiveness and a challenge in both the POPs protocol and first sulfur negotiation, and uncertainty was exploited to stall processes in all three cases.

3.5. Conclusions: Effectiveness in LRTAP Assessment

Analysis of three of the protocols to the LRTAP convention shows that there are several areas in which participants' citation of LRTAP's assessment processes as particularly effective seems warranted. The three assessment processes examined here exhibit particular effectiveness in their establishment of a common scientific basis from which to build further negotiations, and in their use of science to channel debate and establish common methods for analyzing further action.

Assessment processes in the LRTAP convention, therefore, showed similar dimensions of effectiveness over a broad range of issue areas, from sulfur to POPs. The assessment processes differed substantially among the three cases, but the context of the LRTAP convention -- its parties, working group structure, and broad procedural rules -- stayed constant. But the question remains: to what extent were the similar dimensions of effectiveness in the three cases a product of variables of context or process common among the three protocols and established in the LRTAP context, or a result of special circumstances and elements specific to each case? This question is the subject of section 4.

4. INFLUENCES ON EFFECTIVENESS

Examining LRTAP's sulfur and POPs protocol assessment processes through the lens of a progressive view of effectiveness shows similar dimensions of effectiveness among all three of these protocols to the LRTAP convention. The question remains, though, the extent to which these commonly effective outcomes are a function of elements of the assessment process common among these protocols, or of variables unique to each.

Identifying variables that influenced effectiveness in LRTAP's sulfur and POPs protocols can provide a way of analyzing what characteristics of assessment processes might contribute to effectiveness over a broad range of issue areas. If particular variables common among LRTAP protocols influenced the dimensions of effectiveness seen across the three cases, then these common variables might be applicable across other different sorts of assessment processes. Therefore, if one seeks to analyze how participants might draw parallels more critically in scientific assessments, finding whether common variables influenced effectiveness in LRTAP's sulfur and POPs protocols is a crucial step in drawing lessons from these experiences.

In LRTAP's sulfur and POPs protocols, assessment processes successfully established a common basis for negotiations, used credible and relevant scientific evidence, and channeled debate. This section will examine the processes which influenced these effective outcomes, and examine whether factors common among these three LRTAP protocols influenced the dimensions of effectiveness observed in the use of science in negotiations. It will ask the question: what elements of these assessment processes influenced these effective outcomes? Conversely, what elements of assessment processes allowed negotiators to avoid the pitfalls that signal an ineffective outcome? It will do this by analyzing the causal pathways by which these factors might influence outcomes.

This section will go through the three major categories of variables that might influence progress in the LRTAP protocols examined, and analyze how these variables influenced particular dimensions of effectiveness in the three protocols. Section 2 proposed possible pathways by which these categories of variables -- *context, content*, and *process* -- could influence the particular dimensions of effective outcomes identified. *Context* variables here refer to the institutional structure and the background upon which assessment takes place; *content* variables encompass the actual information conveyed in an assessment; *process* variables are those that involve the way in which assessment activity is carried out. The context, content, and process variables will be considered the independent variables in this analysis. The major ways that will be considered here by which variables of context, content, and process can influence effectiveness are through *credibility* and *relevance* as intermediate variables. It is the variables of content,

context, and process that will be analyzed for their influences on effectiveness, in order to determine whether they might serve as common elements of an effective assessment process that could contribute to lesson-drawing. The pathways by which these elements might influence effectiveness are credibility (both scientific and political) and relevance. The variables of context, content, and process will be examined relative to counterfactual examples of how science avoided certain pitfalls that tend to stall issue progress in a variety of different settings.

4.1. Variables of Content

The first category of variables that might be influences on the dimensions of effectiveness seen in the three LRTAP protocols examined is the category of content variables. Variables of content include the material actually conveyed in an assessment, qualities specific to a particular issue such as the ability to model a pollutant, and the degree of scientific certainty. Two specific content variables emerge from interviews and research on the sulfur and POPs protocols as candidates for influences on effectiveness. These are the degree to which the science itself is uncertain, and the influence of specific methodologies of analysis.

4.1.1. Scientific Quality and Uncertainty

It is difficult to speak of qualities that are intrinsic to the science itself, because negotiators and negotiations give the content of the assessment its meaning. But to the extent that negotiators consider certain qualities of science to be, in a sense, outside their control, these are the qualities that are at issue here. These qualities indeed are hardly "intrinsic," but they are constructed in forums and communities that negotiators consider out of their reach. These qualities will be referred to, from the point of view of those involved in negotiations, as those of science "itself" in the analysis to follow.

Given the conditional character of these variables, the question remains to what extent these qualities of science such as its conclusiveness influence dimensions of effectiveness. From the point of view of negotiators, was science so conclusive and deterministic of the need for action that it was the content of the assessment itself that pushed parties to act? The mechanism by which such variables might influence effectiveness is relatively straightforward: if science becomes more certain, it would tend to be more credible both scientifically and politically to negotiators, who would be more likely to reach consensus on a scientific basis for further action. Considering only the sulfur protocols, one might argue that the relative certainty of the science was a large influence on the high degree of consensus on a basis for action, one of the dimensions of particular effectiveness in that case. Levy (1993) argues that at least on the initial question of whether long-range transport of sulfur occurred, the science of the Cooperative Program for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP) served to convince countries by the early 1980s that transport occurred. The determination of long-range transport was indeed an important piece of the basis for action. One might make similar arguments about the other pieces which formed the basic scientific consensus; that is, the science was so compelling, the damage so obvious, that the strength of the science convinced parties to agree on certain basic principles. If one looks at the rhetoric employed by parties in

justifying their agreement on the scientific basis for action, it is tempting to take at face value the governments' claims that they have agreed to act because of the compelling nature of the science. For example, when one delegate mentioned that in the sulfur negotiations the science came in to "prove" that the UK and Poland were "sending their dirt to Sweden," as noted in section 3, he was making the implicit assumption that the science could indeed be determinative in and of itself.

Examining these influences more rigorously in the sulfur protocols, and comparisons to the POPs protocol, however, offer a caution to those who might credit content variables with a substantial influence on dimensions of effectiveness. If it were true that qualities of science itself had a large degree of influence upon forming a basis for further negotiations, one would expect that similar science would lead to similar degrees of consensus across different parties. Additionally, this would predict that on issues where science was clearly either more or less deterministic, one would see a different outcome with regard to the ability of that science to form a basis for decisionmaking. Even looking specifically only at the sulfur cases, the first claim does not hold up. A prime example of similar science leading to different degrees of consensus on the scientific basis for action can be seen in the comparison of Britain to Germany in early years of the acid pollution issue. Though both countries had access to similar scientific research, political situations in the two countries resulted in a drastically different position on whether this science justified preventative action (Boehmer-Christiansen and Skea 1991). On the second point, the comparison with the POPs case shows this to be a problematic claim as well. The science of the POPs issue relied on disciplines and types of evidence which are inherently more uncertain, and less deterministic, than the relatively straightforward modeling of sulfur deposition and the influence of acidification. In the POPs case, human health was an endpoint of concern, and science rested on toxicological data for proof of causation; this science was less deterministic than the sulfur science. However, the differences in qualities of science between POPs and sulfur did not result in a difference in the ability of such science to form a basis for decisionmaking. If anything, POPs science formed a stronger basis earlier in the process than did acidification science, based on the number of parties who agreed upon the scientific basis relatively early, and the relative degree of controversy on basic science.

4.1.2. Specific Scientific Methodologies

If the certainty of science did not have a substantial influence on effectiveness, then did the specific types of scientific analysis employed have a significant influence on effectiveness? Was the ability to trace pollutants from source to sink, one of the particular qualities of the sulfur issue, a major contributor to effectiveness? Analysis similar to that above leads to the conclusion that this was not a particularly strong influence on effectiveness in this case. If it were, one would again expect that the degree of credibility leading to consensus on core science would not vary across countries; the degree of credibility afforded science, however, did vary.

Examining the sulfur protocols in comparison to the POPs protocol reveals that qualities of science such as scientific uncertainty and the specific methods employed to analyze issues have a smaller degree of influence on assessment effectiveness than one might suspect. However, in the limiting cases -- for example, where science has substantial technical problems -- these variables may have a very large degree of influence. A hypothetical example is illustrative: consider an assessment process in which scientific information did not meet what might be considered minimum requirements for scientific adequacy. For example, the assessment might use faulty

emissions estimates or clearly misleading statistical analysis. In this case, qualities of science would lead directly to difficulties in gaining credibility, which in turn would prevent consensus on basic science from occurring. The LRTAP assessment experience, however, suggests that in a case where science can avoid the obvious pitfalls of adequacy problems, degrees of scientific certainty and the use of particular methods of analysis have little influence on effectiveness. It is possible as well that any issue that succeeds in getting onto LRTAP's agenda might have passed a moderate hurdle of internationally acceptable science. Because LRTAP is considered a convention that is at least informed by science, parties would likely not agree to address an issue for which science was particularly questionable. In a hypothetical example, if a party put forward such science, questions about it would emerge relatively early in its issue progress, because a basis of science is considered a prerequisite for addressing an environmental problem under the LRTAP convention. The issue would likely never get onto LRTAP's agenda.

4.2. Variables of Process

If qualities of content are not substantial determinants of effectiveness, then it must be that either variables of context or process are more influential. Process variables are those that involve the way in which assessment activity is carried out. Variables of process, such as participation and methods of science-policy communication, can differ substantially across different negotiations, and indeed vary across LRTAP protocols. Process variables, as considered here, are more easily influenced by participants in negotiating processes than either variables of context or content. A few key variables of process are particularly important to examine in these cases: participation, communication, adaptability, and the setting of realistic expectations for scientific input. In the cases of the three protocols to the LRTAP convention examined here, particular conclusions emerge about what sort of participation and communication processes might tend to influence the probability of effectiveness.

4.2.1. Participation

Participation in assessment activity emerged as a variable of process that had a significant influence on effectiveness in negotiations of LRTAP protocols. Participation as a concept has many dimensions: disciplinary participation in assessment activities, the participation of nongovernmental representatives, and the breadth of participation of different national actors are all elements of participation. However, it was particularly international participation that negotiators most often mentioned in interviews as an influence on assessment effectiveness.

Interviews with participants in the LRTAP process have clearly indicated that international participation is seen as a key influence on the credibility of scientific assessments in negotiations, as well as the propensity for a party to agree that such assessments form a basis for further work. In this way, participation can influence all three of the analyzed dimensions of effectiveness: the ability of science to set a basis for further work, provide credible and relevant evidence, and institute a common method of evaluation. In general, participants espouse the view that the more international the science, the more likely it is that it will be accepted by parties. One participant stated this view in the case of evaluating substances in the POPs protocol, positing that "if a

country that fulfills a task has...some views on how they want to have it in the protocol, that influences the science behind the task they took upon themselves."[46] That is, a country performing scientific assessment tasks runs the risk of having their conclusions challenged based on its political positions. If a particular assessment is considered suspect, this will have several ramifications for the effectiveness of the process. For example, participants will be less willing to accept that science as an authoritative basis for further work, as a "core" that is off the negotiating table. Assessments influenced in such a way will provide less credible scientific evidence for justifying decisionmaking. Wettestad (1997) writes that LRTAP's "diverse scientific-political complex, with the well-functioning EMEP monitoring system as a solid core, provided information crucial to the progress of the process, especially in the early 1980s." The argument can be made that EMEP's characteristics as an international institution and not a domestic program certainly helped its conclusions to be widely accepted, and therefore the formal institutionalization of science had a significant influence on policy progress.

However, comparison with the POPs protocol negotiations leads to the conclusion that the issue of participation is significantly more complex than an initial interpretation of LRTAP would lead one to believe. Particularly, the POPs experience shows that citing "international science" as the key influence on LRTAP assessments' effectiveness is likely too simplistic an explanation. The character of "international science" was significantly different among the three protocols examined here. The contrast between the fully institutionalized science under EMEP and modeling programs and the criteria and assessment work done on a lead country basis in the POPs protocol negotiations is important. One delegate was explicit about it: "In acidification we have institutionalized the science. We have EMEP, we have the effects community doing their programs, and they make their findings public, and they have reports, they have meetings, etc. In developing the POP protocol, you have lead countries doing certain aspects of the work....And this is different science than we are at the moment using in acidification."[47] The results of lead country science in the POPs protocol assessment process were brought to the process through international task forces and working groups; however, the assessments themselves often remained unchanged. The comparison between the POPs protocol and the sulfur protocols, therefore, offers an opportunity to distinguish fully institutionalized science from internationally accepted science, and to determine what qualities of international participation are likely to lead to a greater degree of effectiveness.

The examination of participation by Central and East European countries in LRTAP science by VanDeveer (1998) adds much detail to the determination of what types of participation in LRTAP science matters. He particularly notes the low level of participation of "peripheral" countries in so-called "international" LRTAP science activities. Shaw (1993) argues that the acceptance of scientific research as the basis for LRTAP negotiations was due to the international nature of the scientific and technical work that was carried out under the umbrella of the convention. But is the institutionalization of LRTAP science as international, notwithstanding the unequal participation of parties, really the key to successful assessment in LRTAP? Or does science done on a lead country basis but presented and vetted internationally contribute to agreement on basic science as well? If one is designing an assessment process, would it be easier to form a consensus on a scientific basis for further negotiations if science is done internationally, or, alternately, if non-international science is incorporated into policy-relevant assessment through an internationally-represented process? It has been argued, for example, that the RAINS model would not have been accepted if it had been designed by an institution such as RIVM

(Institute for Public Health and the Environment, Netherlands) rather than IIASA, an international institution.[48] Was the effectiveness of the assessment process here a function of the international character of science, or the international cover of national science?

The POPs protocol assessment experience shows that fully institutionalized science is not a necessary prerequisite for science to form a basis for further progress. Science in the POPs case was almost exclusively national. Much of the initial scientific work was performed by Canada; though the Task Force was international, a small subset of LRTAP countries participated on a voluntary basis, and the process was pushed largely by the influence of Sweden and Canada. The data and assessments collected and analyzed by the early LRTAP POPs groups came mainly from national programs or academic science; the science that was conducted with relevance to international policy involved a very limited subset of LRTAP parties -- for example, the arctic countries or the North Sea region. However, the science put forth by the Task Force was seen as authoritative and credible even by parties who did not participate in the assessment activity.

A closer look at the sulfur protocols, particularly the first sulfur protocol, shows that this the use of national science in this way is not unprecedented in the LRTAP convention. Indeed, though well-institutionalized science was established early on in the sulfur assessment process, many assessments done on acidification issues were national in character (Cowling 1982). Many of these early national assessments contributed to the early conceptions of acid as a problem.

Though the POPs protocol assessment experience shows that fully institutionalized international science such as EMEP is not necessary for assessment to form a basis of concern for further action, to what effect is science internationalized at all? The POPs protocol assessment process shares with similar processes in the sulfur protocols at least the trappings of internationalization. For example, national assessments entered the process largely under international cover, at least those assessments which sought to form a common core of concern among parties. Is this element of international participation necessary for assessment to be effective in forming a basis for future action? One might answer this question by asking whether the results of the Task Force report in the POPs negotiation would be looked upon by negotiators as similarly credible if it had been the product of a purely national assessment, without international cover. Judging by the suspicions voiced of national science by participants in the process, national assessment probably would not have been as credible. Additional evidence for this can be seen in the reaction to the "national" science put forward by the United States in the case of pentachlorophenol; it was not seen as fully credible because of the U.S. interest involved. Therefore, though an international institution such as EMEP is not necessary to lend sufficient credibility to assessment such that it could form a basis for negotiations, some international vetting is clearly necessary.

The necessity of international science for basis-setting does not preclude the possibility of national science contributing to other dimensions of effectiveness. In the pentachlorophenol example, countries found the evidence provided by the United States significantly less credible because of the U.S. interest in keeping pentachlorophenol off the protocol. But the science that the U.S. questioned was its own; and since it is a reasonable assumption that a country is even less likely to criticize its own nationally certified science than even international science, the effectiveness of the process most likely would not have been different if this science was done

internationally. In addition, as is argued in section 3, the process was able to sidestep this pitfall of unreliable evidence by creative use of scientific information, as well as taking advantage of the adaptability of the process. The science was credible enough for other parties to use as justification for decisionmaking. Therefore, in evidence-provision, it is not clear that the outcome would have been substantially more effective had science been international. National science, indeed, had a clear role in promoting effectiveness here.

On the matter of participation, the POPs case certainly offers a caution against interpreting fully institutionalized international science as the key element of an effective assessment process; this case reinforces the need for a more nuanced look at the necessary dynamics of participation. Internationally vetted science is likely necessary in order for scientific assessments to form a basis for further negotiations, but in promoting other dimensions of effectiveness, particularly evidence-provision, international science may not be necessary.

4.2.2. Communication

One of the hallmarks of the LRTAP assessment process is its repeated, iterative communication process. A senior negotiator said that the LRTAP convention offers a chance for policy advisers to participate in development of science both in preparatory work and in negotiations, and also for scientists to gain understanding of the political process. He characterized this interactivity as the *modus vivendi* of the convention.[49] One negotiator noted that there was a higher level of technical knowledge among LRTAP negotiators than in many global negotiations.[50] The process by which policymakers learned the technical details of particular issues was much commented on. A scientific participant noted that during the ongoing process of sulfur negotiation, more policymakers came to understand the details of the modeling work.[51] It is often difficult to tell in the LRTAP assessment process who is participating as a "negotiator" and who is considered a "scientific expert." Often, participants play more than one role. One participant identified himself in an interview as a "scientific advisor/delegate."[52] Negotiators have also been looked to as scientific interpreters in negotiations; one particular participant was asked to answer several scientific questions during the final stages of the POPs negotiation.[53] A comment by a LRTAP negotiator speaks to the way in which science is viewed: he noted that from a policy perspective, science is not so definitive that you can say "policy people ought not to mess."[54] In his view, therefore, policymakers need not sit back and allow science to come to its own conclusions; policymakers can and should shape the direction of assessment activity. Communication between policymakers and scientists is integral to the workings of this type of process. The processes by which policymakers and scientists communicate in LRTAP assessment, therefore, are candidates for influences on the dimensions of effectiveness seen in these processes.

The repeated communication and interaction between technical experts and policymakers reinforced the international character of the assessment exercise, and influenced effectiveness through increasing assessment's policy legitimacy and relevance. The shared value base of the LRTAP convention added credibility to the science, and reinforced this work by building on the experiences of scientific collaboration. This credibility and relevance both increased such an assessment's ability to form a basis for negotiations, provide evidence, and institute a common method of evaluation.

The early assessment work of the POPs protocol was marked by repeated communication between the assessment body of the Task Force and the established LRTAP Working Group on Effects. A senior member of the Working Group on Effects said of this process in an interview that the Working Group on Effects was used to slow down the process of deciding what to do about POPs, and also that repeated communication between the Task Force and Working Group on Effects was used to get parties to understand the need for the LRTAP convention, widely considered an acidification convention, to address this issue. He noted that the Task Force reported to the Working Group on Effects, and that "the Working Group on Effects kept [the issue] for like two or three years, and we push it back saying we want more of this, we want more of that, what were they saying, we want more. And they finally produced a couple of very good reports summarizing the case, and giving a massive amount of scientific information...."[55] He credited this communication process, particularly the time element, as an important factor in influencing the credibility and authoritativeness of the science behind the POPs negotiations; through this, communication became an influence on the broad feeling of consensus that emerged. The repetitive influence of the Working Group on Effects, therefore, served to legitimize the scientific assessment work that was occurring on a lead-country basis within the Task Force, as well as reinforce the need for consensus before moving forward.

To look particularly at the influence of this communication process, one might ask what would have happened had the repeated communication between the Working Group on Effects and the Task Force not been able to occur. There would have been little opportunity for a LRTAP institution to evaluate the work of the Task Force before it issued a final report. Given the skepticism of many involved in the LRTAP context surrounding what they felt was an acidification convention addressing issues outside its purview, the Working Group on Effects would not have been able repeatedly to delay action in order to get used to the idea. Therefore, an initial effort by countries to encourage action on POPs might have been rebuffed. Alternately, if the issue did somehow succeed in getting past these obstacles and onto the LRTAP decisionmaking agenda, weaknesses in an assessment report's relevance to policy might have opened it up to criticism from policymakers who saw holes in its analysis. However, the communication with the Working Group on Effects in early phases gave those preparing the report a systematic way to find out what policymakers needed more information on; therefore, the report could be more immune to such criticism later.

In addition, the scientific legitimacy of selection of substances and the criteria process also benefited from science-policy communication. The selection of criteria was informed by those substances that policymakers wanted to address in the protocol. Like other LRTAP protocols, the POPs protocol for many countries in Western Europe represented a codification of existing regulations rather than a move beyond domestic regulatory authority. One U.S. delegate described criteria selection as "*a posteriori* science."[56] No quantitative scientific basis exists for selecting criteria thresholds; that is, no scientific "bright lines" separate POPs from non-POPs (Rodan *et al.* 1998). However, the communication process between science and policy in substance selection legitimized heavily politicized science and helped to establish criteria as a common language for evaluation.

Similar sorts of processes facilitated effective outcomes in the cases of the sulfur protocols. In the case of the early LRTAP scientific consensus, the early assessments, such as the OECD work of the 1970s, were scientific enterprises conducted in a political forum. The degree of consensus was therefore reinforced by political activities in communication with scientific ones. Levy (1995) cites LRTAP's "collaborative science" as important for "advancing the state of consensual knowledge" of acidification. He notes that the Working Group on Effects and the European Monitoring and Evaluation Programme (EMEP) oversaw collaborative research. In the case of the second sulfur protocol, Alcamo, Shaw, and Hordijk (1990) note that a primary guideline for development of the RAINS model was its formulation as a collaborative effort by analysts, experts, and potential users.

Communication, therefore, emerges as a common principle contributing to effectiveness in all three protocols. In these cases, communication was most effective when it allowed policymakers and scientists repeatedly to shape the construction of assessments in ways that made them more credible and relevant. Repeated policy guidance into science -- that is, an iterative assessment process -- has promoted effectiveness in the case of LRTAP protocols. Communication ensured that the results of the assessment process were relevant to policy, by influencing the ways in which science was conceptualized as policy-relevant. Through reinforcing the international nature of assessment in working group settings, it contributed to the political and scientific credibility of assessment processes. Through these influences, communication was able to facilitate the agreements on science that set a basis for further work.

4.2.3. Adaptation

Another characteristic of the LRTAP assessment process that has tended to contribute to effectiveness is the adaptation seen in the assessment and negotiating processes. Adaptation here will be defined as responding to changes in science, or modifying science-based conclusions at later times. Adaptation as considered here is a process variable, because assessment processes can be designed as more or less adaptable. For example, processes could range from virtually inadaptable -- a process in which all decisions were final -- to completely adaptable -- in which any and all decisions could be changed at any time. It is clear that either of these extremes would likely signal an ineffective process: in the former case, changing information or preferences cannot be taken into account, and in the latter, policies have no measure of predictability, making rational efforts for compliance nearly impossible. Analysis of assessment processes under LRTAP's sulfur and POPs protocols can help distinguish the degree and type of adaptability most likely to promote effectiveness.

The LRTAP convention is an instrument that has been changed repeatedly over its 20-year history by the addition of successive protocols. In assessment, it is clear from the progress from the first to second sulfur negotiations that new scientific information can be incorporated into the convention as well. A particular type of adaptation that contributed to effectiveness in the LRTAP assessment processes was the ability of the process to put off science-based conclusions to a later date, with confidence that they would indeed eventually be addressed.

All three protocols examined occurred shared a sense of adaptability in their assessment processes. In the first sulfur protocol, the agreement that this protocol would be a first step, to be followed by further reductions of emissions in a subsequent protocol, reinforced the idea that the

decisions made would not be the last airing of the issue. The second sulfur protocol occurred in a history of iterative protocol negotiations, in the context of LRTAP's history of repeated addressing of regulatory issues. In the POPs protocol negotiations, adaptation was built into the protocol, in the establishment of a procedure and criteria for adding substances to the protocol. The protocol itself, therefore, exhibited qualities of adaptability.

Adaptability in LRTAP protocols influenced effectiveness through a process that lowered the threshold of credibility seen as necessary for further action. Because the protocol process was adaptable, meaning that a decision taken was not necessarily the final say on a particular issue, this allowed less credible science to move the policy process forward. In the first sulfur protocol, the assumption that the sulfur issue would be revisited allowed parties to view the 30 percent reduction goal as a first step. One delegate said of the debate over sulfur regulations that the countries opposed to regulation "were citing an unsatisfactory scientific base for such a thing, and of course in a sense they were right, but the function was to simply start the ball along."[57] The science, in his opinion, did not have to be completely determinative because of the adaptability of the process. In the case of the POPs protocol, a similar mechanism was at work in the issue of pentachlorophenol. Because the protocol was adaptable, a decision not to address a substance on the initial list did not mean that the substance would never be addressed. In the case of pentachlorophenol, it was this option that lowered the barrier to countries' accepting U.S. science. One delegate mentioned that "we decided rather early that we tried to...find a solution, tried to find a compromise and a protocol, and then anticipate that there would be a second step."[58] A Swedish delegate made it clear that the adaptability of the protocol factored into his country's decision to forego action on certain controversial substances. After mentioning his difficulties with the science itself, and the political realities of the U.S. not signing the protocol with pentachlorophenol included, he added:

> At the same time, we said, let's go and look upon this once more after the protocol....not only pentachlorophenol, but also other substances such as chlorinated paraffins that we wanted in. Further substances. So now the next step is once more to go back to science, and really look if there are loopholes that we have to some way or other try to close. If necessary, bring in further research to assess what's been going on.[59]

The option to put off a policy decision on certain substances facilitated the use of U.S. science as sufficiently credible for moving along the policy process, and thereby contributed to scientific effectiveness in the POPs case. If delegates had not had this option, in contrast, the science put forth by the U.S. would likely have been questioned more rigorously by countries favoring regulation, because not addressing pentachlorophenol would have been a final decision; this would have stalled the negotiating process further.

Adaptation in LRTAP assessment processes also offered a way for compromises, particularly on scientific issues, to be made along another dimension -- that is, it added a temporal dimension for compromise. This was particularly evident in the POPs negotiation. Many issues of contention in the POPs negotiating process, particularly between North Americans and Europeans, were based on underlying differences about the nature of precaution and unacceptable risk. Where, for

example, the U.S. regulates substances based on calculated evidence of risk determination. Europeans tend to take a more precautionary approach. A U.S. negotiator expressed the difference between U.S. and European regulatory policy as a difference between regulations based on hazard and risk. He defined hazard as the quality set that is inherent to a particular substance, and risk as going beyond hazard to say that the substance poses actual harm to the environment or human health, and said of the difference, "We regulate from the risk standpoint, the Europeans tend to regulate from the hazard standpoint."[60] Europeans, particularly Nordic countries, tend to take more precautionary approaches to chemical policy. The same U.S. delegate noted of the difference in regulatory strategy, "The negotiation was in a sense for far too long a contest between these two systems to see which one would be the rule of the road."[61] This difference set up a dynamic in which one set of parties believed that science was sufficiently credible for including a certain set of substances, and another set of parties believed science was too uncertain. A compromise between the two sides would most likely result in some substances thought by the former group to be good candidates for the protocol being left unregulated. However, the adaptability built into the POPs process allowed this compromise to have another dimension -- countries could agree to revisit those substances at a later time, a decision that satisfied both sides. Had negotiators in this case been forced to compromise by a process in which decisions could not be revisited, the negotiation would have faced the pitfall of possibly irresolvable debates about whether the science on these additional substances was credible enough to support inclusion on the protocol. This would have stalled negotiations by promoting debates on uncertainty, while other, more certain substances remained unaddressed.

That policymakers were able to put off certain decisions to future negotiations that they were confident would occur contributed to the effectiveness of assessment in all three protocols. That this sort of adaptation to further science could occur allowed parties to make compromises not only between science and policy, but also along a temporal axis. The concept of making compromises in this sense is related to the discussion in section 2 of the concept of "serviceable truth" (Jasanoff 1990). Serviceable truth -- defined by Jasanoff as "a state of knowledge that satisfies tests of scientific acceptability and supports reasoned decisionmaking" -- deals with decisions made through negotiation about the boundaries between and the categories of science and policy. Adaptation in the LRTAP protocol assessment processes achieved agreement on useable knowledge by making similar compromises along a temporal axis. That adaptation served this function in the LRTAP assessment processes raises the possibility that the concept of adaptation might usefully be employed as a temporal dimension of "serviceability."

4.2.4. Realistic Expectations

A final variable of process that emerges as important in analyzing these three LRTAP protocols is the degree to which delegates are able to communicate realistic expectations of the information and recommendations scientists can provide. LRTAP assessment processes have exhibited skill in not asking too much of science; that is, negotiators did not demand more of science than science could provide.

Demanding too much of science -- or, not recognizing the limitations of current scientific knowledge -- is a well-recognized pitfall of assessment. In many cases, if policymakers had pushed science to make conclusions prematurely, it is clear that the progress of the assessment

process would have suffered. One has only to look at the case of stratospheric ozone, as discussed in section 2, for an example: had the "Blue Book" assessments attempted to address Antarctic ozone science, the assessment's credibility would have been compromised, and the process would have stalled (Clark *et al.* 1996). If policymakers demand too much for science, they have constructed the process in a way that makes falling victim to pitfalls more likely.

Looking specifically at the LRTAP protocols, it is clear that had policymakers pushed science further than scientific principles would allow, the credibility of science in the process would have suffered, and assessment would have been less effective. Policymakers, indeed, were conscious of the limitations of science, and recognized its limitations; at the same time, they did not push science to answer questions that would have entered areas of unwarranted uncertainty. For example, had policymakers insisted on an effects-based analysis of sulfur at the time of the 1985 protocol, the science added to the process would have been extremely uncertain. Such uncertainty would have harmed the credibility of the science, and through this, might have promoted excessive debates. In reality, policymakers were realistic about science's limitations.

In the POPs case, there were two areas in which policymakers stopped short of asking science to address questions that it could not answer well -- in conducting substance assessment and selection, and determining whether there would be "critical loads" for POPs. In selecting substances, policymakers did not push science to make assessments of substances for which sufficient data was not available. One delegate said that there was "a lack of knowledge on a lot of substances," and noted that "when there were question marks around substances we left them, or when they were to tricky, we left them, because of lack of science."[62] This prevented uncertainties on marginal substances from becoming an unwarranted focus of negotiators' concern. During the POPs negotiations, policymakers and scientists also discussed whether critical loads were a viable concept to use in addressing POP substances. One delegate said that there was, "partially because the concept of critical loads is so dear to many, an effort to try to bring in that type of concepts also in POPs and metals. POPs I think the scientific assessment is no, that's not the way to go." Policymakers were realistic in their acknowledgment that the state of the science would not support a critical loads analysis of POPs -- and that the POPs problem may always be incompatible with a critical loads-type approach. An example of realistic expectations for critical loads analysis can be seen in the communications between the Working Group on Effects, the Working Group on Strategies, and assessment activity on critical loads for POPs. The Working Group on Effects and the Working Group on Strategies encouraged the exploration of methodologies for effects-based approaches for POPs. An scientific workshop held in November 1997 on critical limits for heavy metals and POPs, jointly sponsored by the Netherlands and Germany, explored this issue; it recommended that further negotiations draw a clear distinction between risk assessment procedures and critical loads approaches that included mapping. The former were recommended for POPs.[63] In light of that scientific assessment, there was a level of agreement among negotiators not to push science towards a critical loads approach, and a realization the limitations of such analysis for these substances.

Had negotiators pushed scientists too hard on answering questions that could not adequately be addressed by current science, the credibility of scientific analysis would have suffered. In the

LRTAP protocols, the ability of policymakers to establish reasonable expectations of science, therefore, contributed to the effectiveness of assessment activity.

4.3. Variables of Context

The final category of variables that are candidates for influences on effectiveness are variables of context. Context is the background within which negotiating activity takes place; it is a function of the larger institutional setup and interactions. In the assessment processes of protocols to the LRTAP convention, elements of context include the structure of the framework convention itself, and the UNECE region. Two main aspects of context contribute to effectiveness in LRTAP assessment processes: these are the setup of the agreement as a framework convention with protocols, and the establishment of shared norms and principles that the LRTAP process has fostered.

4.3.1. Framework Convention-Protocol Setup

That LRTAP is set up as a framework convention, under which a series of protocols are encompassed, certainly contributed somewhat to the ability of assessment to facilitate policy progress. The framework convention setup fostered confidence in delegates that issues would indeed be addressed again; that is, lack of action in a specific protocol did not necessarily preclude later action. In a mechanism similar to the one described for adaptability, this lowered the credibility threshold, and allowed decisions to be made on the basis of science that would otherwise have stalled the process. In fact, the framework convention-protocol setup, and the history of repetitive addressing of issues in the context of the convention, were important factors that influenced delegates' confidence that issues would be revisited again.

The existence of a framework convention, rather than just a series of separate agreements among the same parties, also facilitated assessments' getting issues on the policy agenda. In the case of POPs, it was scientific work that prodded Canada and Sweden to push for international action on these substances, but had LRTAP not existed, the hurdle to organizing collective action on such an issue would have been much larger. LRTAP, however, already existed, and those favoring POPs action were able to use the LRTAP context to facilitate getting the POPs issue on the agenda. If the LRTAP convention had not been in force, it is highly unlikely that large-scale international action on POPs would have occurred in the time frame in which it did. In the same way, the existence of a framework convention provided a vehicle for assessment on the sulfur issue to influence subsequent negotiations.

4.3.2. Shared Norms and Principles

The existence of shared norms and principles is a characteristic of context often cited as contributing to policy effectiveness. Selin (1997), in his comparison of the pre-negotiation phase of the LRTAP POPs protocol process to similar processes for assessing POPs occurring under the auspices of the United Nations Environment Programme (UNEP), credits the LRTAP pre-negotiations process with better promoting the emergence of a jointly held value base. He writes that parties have "benefited from previous successful work within LRTAP, by being able to

partly build on an already existing shared value base regarding issues of transboundary air pollution." Shared norms and principles, or a shared value base, can influence assessment effectiveness by enabling assessment processes more easily to establish the credibility and relevance necessary for the task at hand, facilitating particularly the ability of assessment to form a basis for further negotiations.

One of the key ways in which shared norms and principles influence effectiveness in the LRTAP convention's assessment processes is in parties' shared commitment to science. LRTAP is a convention that has a long tradition of common scientific activity and decisionmaking based on science. Whether or not the decisions taken in particular protocol were indeed based on sound science, the perception of the LRTAP convention as a forum for "collaborative science" (Levy 1995) is prominent in the minds of negotiators. These shared principles and norms can be seen by comparing the text and structure of the final protocols: particularly, the preambles and substantive article procedures. Preambles to international agreements are a place where parties explicitly articulate shared principles. Both the 1994 sulfur protocol and the 1998 POPs protocol share virtually identical language about the need for science and scientific cooperation in their preambles. One particular paragraph in common emphasizes "taking into consideration existing scientific and technical data on emissions, atmospheric processes and effects" of the substances (UNECE 1998). Scientific cooperation is emphasized in the 1998 and 1994 protocols as well, ad is also a common element in the 1985 protocol and the 1979 convention. These shared principles of science in the LRTAP convention helped the assessment process establish a common basis for negotiations in the sulfur and the POPs protocol negotiations, because parties agreed that science would be used in this fashion, and were committed to making decisions at least on paper based on science. One way to get a sense of the norms shared among these protocols is by looking at the structure of substantive articles. The structure of these, particularly procedural, articles are strikingly similar among the three protocols examined, including articles on national programmes, reporting, and, in the 1994 and 1998 protocols, articles on exchange of technology, research and development, and review by the Executive Body. Shared procedural norms can contribute to effectiveness by increasing parties' confidence in the instrument and its procedures. If procedures have worked before, similar structures may work again. This facilitates confidence in the adaptability in the assessment process, by reassuring parties that issues will, in fact, be revisited when compromises are made to address them later.

4.4. Conclusions: Influences on Effectiveness

The preceding sections have identified a number of factors, qualities of LRTAP protocol scientific assessment processes, that are influences on the effectiveness of these processes. These variables contribute to effectiveness by influencing the credibility (both scientific and political) and relevance of assessment processes to international negotiations. Variables that seem particularly important influences on the effectiveness of assessment processes across the sulfur and POPs protocols are those of process and context. Variables of process that are significant influences on effectiveness include international participation, iterative communication processes, adaptability, and realistic expectations of science; variables of context include the framework convention-protocol setup and the existence of shared norms and principles.

What, specifically, does the comparison between LRTAP sulfur and POPs protocol assessment processes say about which variables might be important influences on assessment process effectiveness across issue areas? A few major conclusions emerge. On the matter of variables of content, comparing LRTAP's sulfur and POPs protocols shows that the content of an assessment is not likely to have a significant influence on moving the policy process forward. Differences in the certainty of science or specific scientific methodologies, provided they meet some minimum criteria of adequacy, result in little differential in effectiveness. Variables of process and context emerge as more important influences. On participation, looking at LRTAP POPs and sulfur assessment processes shows that fully institutionalized science is not a prerequisite for successful establishment of a scientific basis for further negotiations; however, in basis-establishment, some international cover is necessary for assessment to be seen as credible for this purpose. On the other hand, a close look at the POPs and sulfur experience shows that in these cases, not all dimensions of effectiveness require even the guise of international science. National science can play an important role, particularly in evidence-provision. Iterative communication processes in these cases reinforced the international relevance and credibility of various different kinds of assessment. The adaptability of a process -- and an individual instrument -- can lower the hurdle of credibility necessary for assessment to be put to effective use. Realistic expectations of science are important for avoiding the pitfalls of allowing a process to become hung up on debating scientific uncertainty. An existing framework convention and protocol system can facilitate assessment effectiveness particularly in the agenda-setting stage; preexisting shared norms and principles, particularly a commitment to science, can also facilitate assessment's influence on policy progress through helping in establishing a scientific basis for further progress.

Of course, each of these influences on effectiveness do not occur in isolation, but within a common context of an assessment process. What can the above analysis say about the relative importance of these factors, acting as a system? Clearly, content emerges as less important than either context or process. Iterative communication and adaptation processes are perhaps the most important influences. In the case of communication, the iterative communication process reinforced the ability of international science to establish credibility and relevance, by establishing a method by which negotiators could consistently provide input into assessment processes. For example, in the POPs protocol assessment process, the Task Force report's use of national science under international cover would likely not have been as successful at establishing a basis for negotiations without the iterative communication with the Working Group on Effects, which ensured that the topics of relevance to negotiators were being addressed, as well as reinforced the international character of the endeavor. Adaptability also allowed negotiators to avoid pitfalls at extremely crucial points in the negotiation, by allowing decisions to be made on relatively less certain science. Had the POPs protocol process not allowed the possibility that the protocol could add substances, decisions would have been seen as permanent, raising the threshold of scientific credibility necessary to inform these decisions. Decisions about whether to include substances or not could not be put off to wait for more certain science. If the first sulfur protocol were seen not as a first step but as *the* sulfur protocol, the lack of a scientific basis for a 30 percent reduction would have taken on more significance. Whereas deficiencies in participation or too ambitious expectations of science, for example, can be compensated for by especially strong influences of other factors, less adaptability would be difficult to overcome with other variables. Context emerged as important; however, the largely shared context among the three protocols examined makes it more difficult to determine its relative influence.

To answer the question posed at the beginning of this section, the dimensions of effectiveness seen in LRTAP protocol assessment processes seem to be influenced by a set of shared determinants common among these processes. Though the application of these principles had important differences across the three assessment processes examined, common lessons emerge from these processes about how variables of context, content, and process contribute to effectiveness. Perhaps not surprisingly, the results of this analysis give evidence that there are certain principles of assessment processes that can influence effectiveness across different issue areas. The examination of these three LRTAP protocols has provided an empirical basis for identifying particular candidates for such variables.

5. LESSONS AND CONCLUSIONS

The negotiations of the sulfur and POPs protocols to the LRTAP convention offer examples of scientific assessment processes that, in many ways, have been effective in moving the policy process forward. Across these different issue areas, there are several common elements of assessment processes that contribute to this observed effectiveness. Particularly important variables influencing effectiveness across these cases include the iterative communication process between scientists and policymakers, and the adaptability built into the LRTAP convention, its protocols, and their assessment processes. Communication between scientists and policymakers promoted effectiveness in forming a basis for future work, by ensuring that assessment results were relevant to policy, and reinforcing the international nature -- and thus the credibility -- of the assessment activity. Adaptability, specifically the ability to put off decisions on controversial science to a later time, lowered the threshold of credibility necessary for policy progress; this allowed science to serve as evidence to facilitate further action. In seeking to understand the LRTAP convention and its assessment processes, the comparison of assessment processes under the sulfur and POPs protocols offers an explanation for the factors that contributed to effective outcomes.

For those seeking to draw lessons about the design of assessment processes across issue areas, however, what is the significance of this result? What sorts of questions does this analysis raise about assessment processes in other international environmental negotiations? This section will explore how the influences on assessment effectiveness identified as common contributors toward policy progress in LRTAP protocols might serve as an empirical basis for lesson-drawing. It will address the question of how generalizable principles for effective assessment might be across different issue areas. It will examine the advantages and limitations of the definition of effectiveness employed in this paper, and ask whether this concept of effectiveness might be a useful one to apply to analysis of other issues, in other contexts. It will address the relevance of this particular analysis in the context of studies of assessment processes and the use of science in policy contexts. Finally, it will draw a few tentative conclusions and pose some questions and hypotheses about how particular determinants of effectiveness might apply to other international environmental issues. Issues of lesson-drawing are very close to the boundary between practitioners and scholars of assessment; lesson-drawing is as likely to become more informed by further participant reflection as more academic analysis. Therefore, the questions and hypotheses generated by this research are designed to serve as a guide both to policymakers who seek to

design assessment processes, as well as to analysts seeking a better understanding of scientific input into policy.

5.1. Lesson-Drawing across Issues

For policymakers who hope to draw lessons from previous policy experiences, determining the conditions under which a program might work effectively is crucial. Rose (1991) argues that lesson-drawing is often a matter of prospective evaluation, in which a program that works in a certain situation is evaluated as to its possible effectiveness in another. Comparing the effectiveness of policies across different situations can provide an empirical basis for making inferences about prospective evaluation. Rose addresses this in the case of transferring programs across countries: "Logically, the observation of differences could lead to hypotheses about whether a program now in effect in country X would be effective if transferred to country Y" (1994).

The examination of scientific assessment processes in LRTAP protocols can offer just such an observation. Similar processes of institutional setup, particularly communication processes and institutional adaptability, contributed to effective outcomes in all three cases. In this analysis, the institutional context of assessment -- the forum of the LRTAP convention -- was relatively constant across the three cases, while the content and qualities of the issue, as well as particular details of the assessment process, varied. The lessons that might be drawn from this comparison, and the conclusions of this analysis, are relevant therefore to the transferability of those elements of assessment processes that influence effectiveness across different issue areas.

In most negotiations on transborder environmental issues, policymakers seek to draw lessons both across different issue areas and across different contexts. Though the conclusions from this comparison cannot offer a concrete basis for both of these types of generalizations, it can suggest what questions policymakers might ask about assessment process design, and propose certain design elements to which policymakers should pay particular attention. In particular, the results of this analysis suggest that policymakers should look carefully at elements of process in designing assessment. They might ask what degree of international participation is necessary for the task at hand; pay particular attention to the structures and institutional arrangements for communication; consider the degree of adaptability built into the assessment process; and be careful to have realistic expectations about what science might provide. The LRTAP experience suggests a number of hypotheses about the correspondence between elements of assessment design and effectiveness in general, which might serve as the basis for such lessons:

- **Iterative communication processes, in which scientists and policymakers can discuss assessment activity, increase the effectiveness of scientific advice processes.** The finding that iterative communication processes influenced effectiveness in the LRTAP protocol assessment processes is significant, because it challenges the view entrenched in many assessment processes that science and/or scientists should always be disinterested, indirectly relevant to policy, and kept from direct contact with policymakers. The prime example of an assessment process in which scientists and scientific activities are by design distinctly separate from negotiating processes is the Intergovernmental Panel on Climate Change (IPCC) process. In the case of the three LRTAP protocols examined, it was exactly the

opposite setup that contributed to an effective outcome, particularly with respect to setting a basis for further action.

- **A more adaptable process, in which every decision is not necessarily taken as final, is more likely to be effective than a less adaptable process.** Adaptation -- here defined as the ease with which policymakers may put off particular decisions for addressing in the future -- emerged as a common element influencing effectiveness across the three LRTAP assessment processes examined. The results of this analysis suggest that when policymakers are able with confidence to assure that issues will be addressed later, the policy process can move forward by offering a new dimension of compromise. The existence of a history of repeated addressing of issues -- as seen in LRTAP's convention-protocol framework -- contributes to delegates' confidence that issues put off will indeed be addressed later.

- **Fully institutionalized science is not a prerequisite for an effective assessment process.** A more international process does not always lead to more effectiveness. The difference in degrees of international participation in the POPs and sulfur assessment process resulted in similarly effective outcomes. This suggests that policymakers need not construct fully international institutions for science -- that even assessments that seek to form a basis for future policy progress may be sufficiently credible using national science with international cover or international vetting. Particularly for evidence-provision, even nationally-produced or interest-based science can promote effective outcomes.

- **Scientific uncertainty does not necessarily compromise effectiveness.** This analysis offers reassurance to policymakers concerned about the influence of differences in degrees of scientific uncertainty across issues. Provided some minimum criteria of scientific adequacy is fulfilled, marginal increases or decreases in scientific certainty seem to have little influence on the ability of assessment to facilitate policy progress. The process by which environmental issues reach the international agenda, particularly in the LRTAP context, may self-select those issues that fulfill this minimum criteria of adequacy. This is because LRTAP is seen by participants as a science-based convention, and serious adequacy problems likely would emerge early in the progress of the issue, perhaps preventing the issue from ever getting onto LRTAP's agenda.

What sort of variations across issues are embodied in the range between sulfur and POPs? Over what particular types of issues might the identification of common influences on effectiveness in the POPs and sulfur protocols be useful to policymakers seeking to draw lessons? The analysis presented in this paper particularly emphasized that key influences on effectiveness in both sulfur and POPs negotiations were communication, in the establishment of an iterative communication process between scientists and policymakers, and adaptation, in the ability to put off selected decisions to a later date. The experience of LRTAP POPs and sulfur assessment processes suggests that the following areas of difference might represent issues over which such common elements of assessment process design might contribute similarly to effectiveness. Two areas of difference stand out in particular: the type of chemical, and the ability to model pollutants:

- Commercially-produced chemicals vs. byproducts: The spectrum from POPs to sulfur encompasses two very different types of chemicals: byproducts and commercially-produced chemicals. Despite the significant differences in the ways in which these types of chemicals are assessed and the types of commitments envisioned in addressing problem chemicals in each category, this analysis suggests that the identified influences on effectiveness work across these different chemical types.

- Easily modeled vs. difficult-to-model pollutants: While the path of sulfur in the atmosphere can be traced from emitter to effect, substance revolatilization makes this virtually impossible for POPs. The identification of common influences on effectiveness across these cases indicates that the ability to model pollutants -- to trace a scientific link between the location of source and effect -- has little influence on effectiveness.

One of the key limitations of this analysis, however, is its inability to make very strong inferences about what influence context variables such as shared norms and principles and the framework convention and protocol setup might have on assessment process effectiveness. Because these elements of LRTAP context stayed relatively constant among the protocols examined, detailed predictions about the influences of context variables were beyond the scope of this analysis. The comparison between assessment effectiveness in sulfur and POPs protocols to the LRTAP convention can offer only limited conclusions in the way of lessons for those specifically interested in drawing lessons across context: the existence of shared norms and principles, and a framework convention and protocol structure, tended to contribute to effectiveness in these cases, and therefore might in others.

To policymakers designing assessment processes, the results of this comparison between LRTAP sulfur and POPs assessment processes offer some suggestions for drawing particular lessons. Policymakers who are interested in improving the effectiveness of scientific advice processes, and looking to LRTAP as an example, could look to the hypotheses presented above to inform lesson-drawing. They might want to set up processes which encourage communication between scientists and policymakers, and design institutional frameworks which facilitate this communication. They might also consider setting up an assessment process so that science-based decisionmaking can be put off to later iterations of assessment or negotiations.

In the context of research on science, policy, and assessments, the particular result of this comparison suggests several areas where more research might help to elucidate other lessons from assessment experience. Further examinations might evaluate the degree to which communication and adaptability are lessons across contexts, by examining similar issue areas such as acidification or chemical policy either in global contexts or in different regions. As well, more research could illuminate whether these variables influence effectiveness across very different issues apart from airborne pollution, for example on issues related to biodiversity or conservation.

5.2. Relevance to Study of Assessments

What might the comparison of assessment processes in LRTAP POPs and sulfur protocols add to the study of assessments in general, and of scientific information in international policy contexts?

In the specific area of the LRTAP convention, looking at the POPs protocol, one of the two most recent protocols to the convention, can provide an additional case from which the lessons of LRTAP assessment processes might better be understood. Traditional analyses of the LRTAP convention have looked at its addressing of persistent organic pollutants and heavy metals as anomalous; the more detailed examination here shows that an effort to draw lessons from LRTAP's assessment process is much informed by considering POPs as an important part of LRTAP convention activities and regulatory agreements. Those elements of LRTAP's assessment processes that might have been thought to influence effectiveness only for issues of sulfur or nitrogen pollution are in fact influences on effectiveness over a broader range of issues. The identification of variables that might influence assessment processes across a range of environmental issues provides pointers towards aspects of assessment processes that might be looked at more specifically in further analyses.

Of particular interest here is the way of conceptualizing assessment effectiveness, and the influences on assessment effectiveness, that was applied in this paper to the LRTAP protocols. Effectiveness was analyzed in a progressive framework, relative to its ability to facilitate or stall policy progress. In applying this idea to LRTAP protocols, three ways in which scientific information influences policy progress on specific issues were identified: setting a basis for further action; providing evidence to justify decisionmaking; and focusing and channeling debate. Conversely, three ways in which scientific information stalls policy progress were characterized: promoting excessive debate over uncertainty; failing to provide credible and relevant evidence; and shifting debate to methodological controversies. As described in section 3, scientific advice in the LRTAP protocols did, in fact, influence policy progress in these ways. Influences on effectiveness, broken down into categories of variables of context, content, and process, produce effects via a pathway that includes the intermediates of credibility and relevance. Provided credibility and relevance are sufficient for the task at hand, scientific assessment facilitates policy progress, and therefore can be deemed effective. In the LRTAP assessment processes examined, these causal pathways represented ways in which elements of assessment design influenced policy progress.

This conceptualization of effectiveness seemed to work well in analyzing LRTAP protocols' assessment processes. The emphasis on dynamic aspects of effectiveness was particularly suitable for analysis of a process such as LRTAP's assessment activity, because of the iterative nature of assessment in the LRTAP context. In particular, the dynamic analysis of LRTAP assessment allowed concepts such as adaptability and communication to be looked at more systematically, relative to their influence in the process, rather than what ultimate effects might be.

Could this conceptualization of effectiveness be applied to other assessment processes? The progressive conception of effectiveness employed here has some particular advantages and disadvantages that are made clear by its application to LRTAP assessments. One of the major advantages of using a progressive view of effectiveness is that it allows more direct analysis of the temporal dimension of assessment processes. The ways in which science affected policy progress in the cases examined fit well into such a general characterization of such influences. In addition, the causal pathways by which aspects of assessment processes influenced policy

progress were better delineated with reference to the intermediate variables of credibility and relevance.

This characterization of effectiveness, however, also has important limitations. This paper looked specifically at effectiveness for policy progress, from the reference point of those participating in international negotiations. Effectiveness to different audiences, and for different purposes, would not be well measured by the same criteria. Analyzing the effectiveness LRTAP protocols in this way certainly does not preclude analysis of other sorts of effectiveness. However, focusing on a progressive idea of effectiveness does shape the results of this examination in certain particular ways. No attempt is made to distinguish between different sorts of resulting protocols; whether different sorts of assessment processes would have resulted in more equitable, more environmentally beneficial, or more cost-effective outcomes cannot be determined by focusing on process. Instead, a progressive view of effectiveness focuses on whether policymakers make use of science to facilitate policy progress, without trying to determine what beneficial progress might be.

Other elements of this effectiveness framework might limit its applicability across different assessment processes. The characteristics of the LRTAP process are also a particularly unique fit to this model of effectiveness; the differences between LRTAP assessment processes and others might compromise the utility of these effectiveness criteria. Two important limitations stand out: the relative similarity among parties to the LRTAP convention (at least compared to the great disparities among parties in global negotiations), and the lack of a large direct influence of nongovernmental organizations in LRTAP policymaking, particularly in the case of the POPs protocol. In global contexts, for example, any assessment process must address the concerns of both developed and developing countries; NGOs can also be a very significant presence. Despite these limitations, however, the utility of this conceptualization of effectiveness in the LRTAP process, particularly in addressing dynamic components, suggests that it might serve as a starting point from which further studies might analyze assessment effectiveness.

5.3. Conclusions

Analysis of the scientific assessment processes in the LRTAP POPs and sulfur protocols offers a way to identify what variables of assessment processes promote effectiveness across different issue areas. There are significant differences between POPs and sulfur as environmental issues; however, the assessment processes that informed protocol negotiations on these substances in the context of the LRTAP convention proved to be similarly effective in science's ability to move the policy process forward. Science served several different functions in facilitating the LRTAP policy process: it formed a basis for further decisionmaking, provided evidence to justify decisionmaking, and focused and channeled debate. Science also stalled progress, by promoting excessive debate over uncertainty, failing to provide credible and relevant evidence, and shifting debate to methodological controversies. On the whole, scientific assessment in the POPs and sulfur protocol facilitated policy progress in similar ways; that is, similar dimensions of effectiveness emerged among these experiences. Areas of particular effectiveness included basis-setting and the channeling of debate. Common variables influenced these dimensions of effectiveness across the three cases.

Variables of process -- those variables that involve the way in which assessment activity is carried out -- were the most significant influences on effectiveness common among the three protocols examined. The LRTAP experience suggests that process variables in general were stronger influences on effectiveness than either scientific quality and uncertainty or specific scientific methodologies. Shared norms and principles, and the framework convention and protocol structure, emerged as variables of context influencing effectiveness. Fully international participation, a variable of process, was not a necessary prerequisite for effectiveness; while international cover was necessary for science to set a basis for further work, national science was used to provide evidence for decisionmaking. Most significantly, in LRTAP protocols, the process variables of repeated communication between science and policymakers, and the ability to adapt science-based decisionmaking by putting off decisionmaking to a later time, were key influences on assessment effectiveness.

To return to the question posed at the beginning of this paper, when negotiations on environmental issues are based on very different scientific and political qualities, how can negotiators draw better parallels? The conclusions of this paper certainly do not suggest a universal template of effective assessment process design. However, what the comparison of LRTAP's sulfur and POPs protocol assessment processes can provide is a guide for asking more specific questions about what sorts of structures for scientific input could promote policy progress. It suggests a number of particular hypotheses about variables that might influence effectiveness across different issue areas, based on the influences on effectiveness seen in these cases. As well, it suggests areas in which further research into assessment processes might better enlighten what influences effectiveness across different negotiations. If "Modeled after the Montreal Protocol" -- or even "Modeled after the POPs Protocol" -- is to be more than just a catchy saying among negotiators, this analysis can help to make such lesson-drawing more critical, more reflective, and, perhaps, more effective.

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TABLES

Table 2.1: Ways in which assessments can influence effectiveness

Ways science can facilitate issue progress	Ways science can stall issue progress
1) ***Establishing a basis for further action.***	1) ***Promoting excessive debate over uncertainty***
2)***Providing evidence to justify decisionmaking.***	2) ***Failing to provide credible, relevant evidence.***
3) ***Focusing and channeling debate.***	3) ***Shifting debate to methodological controversies.***

Table 2.2: Pathways for influencing effectiveness

Independent Variables →	Intermediate Variables →	Dependent Variable
Content e.g. scientific analysis, uncertainty Process e.g. communication, participation Context e.g. convention structure	Credibility --scientific --political Relevance	Effectiveness --basis-establishment --evidence-provision --debate-channeling

ENDNOTES

[1] Interview with senior negotiator (#2), December 8, 1998.
[2] e.g., Interview with senior negotiator (#4), December 9, 1998; Interview with senior negotiator (#2), December 8, 1998.
[3] Interview with senior negotiator (#2), December 8, 1998.
[4] Interview with senior negotiator (#7), December 10, 1998.
[5] Interview with senior negotiator (#2), December 8, 1998.
[6] Interview with senior negotiator (#2), December 8, 1998; Interview with senior scientific participant (#12), December 16, 1998.
[7] Interview with senior negotiator (#7), December 10, 1998.
[8] Interview with senior scientific participant (#12), December 16, 1998.
[9] Interview with senior negotiator (#6), December 10, 1998.
[10] Interview with senior negotiator (#7), December 10, 1998.
[11] Interview with senior negotiator (#4), December 9, 1998.
[12] Interview with senior negotiator (#10), December 11, 1998.
[13] Interview with senior scientific participant (#12), December 16, 1998.
[14] Interview with senior negotiator (#2), December 8, 1998; Interview with senior negotiator (#6), December 10, 1998.
[15] Interview with senior European negotiator (#3), December 9, 1998.
[16] Interview with senior Task Force participant (#15), December 9, 1998.
[17] Interview with senior negotiator (#6), December 10, 1998.
[18] Interview with senior negotiator (#7), December 10, 1998; Interview with senior negotiator (#6), December 10, 1998.
[19] Interview with senior North American negotiator (#8), December 10, 1998.
[20] Interview with senior Task Force participant (#15), December 9, 1998.
[21] Interview with senior United States negotiator (#1), December 7, 1998.
[22] Interview with senior negotiator (#16), August 13, 1998.
[23] Interview with senior Canadian negotiator (#17), December 10, 1998.
[24] Interview with senior negotiator (#10), December 11, 1998.
[25] Lars Lindau, Invitation to the first meeting of the Task Force on Persistent Organic Pollutants, Annex II. January 14, 1991. The phrases "persistent organic contaminants," "persistent semivolatile bioaccumulating organic compounds," "persistent organic compounds," and "POC" are used to refer to POPs in several of the early assessments in the LRTAP process.
[26] *Ibid.*, Annex III.
[27] Interview with senior Task Force participant (#15), December 9, 1998.
[28] "Organochlorines in the Environment -- Status Report of the Task Force on Persistent Organic Pollutants." Solna, Sweden, 18-22 March 1991. Annex III in Minutes of the first meeting of the Task Force on Persistent Organic Pollutants.
[29] Interview with senior North American scientific advisor (#13), July 24, 1998.
[30] The final protocol included 16 substances. These were: Aldrin, Chlordane, Chlordecone, DDT, Dieldrin, Endrin, Heptachlor, Hexabromobiphenyl, Hexachlorobenzene, HCH, Mirex, PCBs, Toxaphene, PAHs, Dioxins, and Furans.

[31] Interview with senior negotiator (#2), December 8, 1998; Interview with senior negotiator (#18), December 9, 1998.
[32] Ad Hoc Preparatory Working Group on Persistent Organic Pollutants. Report on the Third Session (Geneva, 8-10 May 1996). EB.AIR/WG.7/6, 18 June 1996. The methodology was presented in a report submitted by the delegation of the United Kingdom (EB.AIR/WG.7/R.3) based on a section of its meeting paper from the 3rd PWG session (Paper 3/4).
[33] "A Concise Review of the Development by the PWG/POPs of the Criteria and Procedure Recommended for Priority Substance Identification." 1996. 3rd Session, Ad-Hoc Preparatory Working Group on Persistent Organic Pollutants (PWG POPs), 8-10 May, Geneva. Paper 3/4. Prepared for the UK Department of the Environment, Air and Environmental Quality Division, by: AEA Technology plc, National Environmental Technology Centre, Culham, Oxfordshire, UK, April 1996.
[34] Interview with senior negotiator (#19), December 7, 1998.
[35] Lindane ((-HCH) was eventually included in the protocol, while short-chain chlorinated paraffins were not.
[36] Interview with senior negotiator (#19), December 7, 1998.
[37] Interestingly, the data in question had originally been provided by the U.S. Environmental Protection Agency.
[38] Interview with senior United States negotiator (#01), December 7, 1998.
[39] Interview with senior European negotiator (#20), December 9, 1998.
[40] Interview with senior United States negotiator (#1), December 7, 1998.
[41] Interview with senior Swedish negotiator (#21), December 9, 1998.
[42] One of the reasons why U.S. participation was viewed as crucial was that the LRTAP POPs protocol was seen as setting a precedent for the global POPs agreement, which had yet to begin negotiations. (Interview with senior negotiator (#02), December 8, 1998.)
[43] Interview with senior United States negotiator (#22), December 8, 1998.
[44] A particular concern with pentachlorophenol is that it can be contaminated with dioxin; this clause is included in a section dealing with research on POPs contaminants. See LRTAP POPs protocol, Article 8(h).
[45] Interview with senior United States negotiator (#23), December 11, 1998.
[46] Interview with senior negotiator (#18), December 9, 1998.
[47] Interview with senior negotiator (#18), December 9, 1998.
[48] Interview with senior scientific participant (#12), December 16, 1998.
[49] Interview with senior negotiator (#7), December 10, 1998.
[50] Interview with senior negotiator (#19), December 7, 1998.
[51] Interview with scientific participant (#9), December 9, 1998.
[52] Interview with scientific advisor/delegate (#5), December 9, 1998.
[53] Personal communication with Stacy VanDeveer, February 4, 1999.
[54] Interview with senior negotiator (#16), August 13, 1998.
[55] Interview with senior member of Working Group on Effects (#24), December 10, 1998.
[56] Interview with senior United States negotiator (#1), December 7, 1998.
[57] Interview with senior negotiator (#7), December 10, 1998.
[58] Interview with senior negotiator (#4), December 9, 1998.
[59] Interview with senior Swedish delegate (#21), December 9, 1998.
[60] Interview with senior United States negotiator (#1), December 7, 1998.
[61] Interview with senior United States negotiator (#1), December 7, 1998.
[62] Interview with senior negotiator (#18), December 9, 1998.

[63] "Workshop on Critical Limits and Effect Based Approaches for Heavy Metals and Persistent Organic Pollutants." Proceedings (Bad Harzburg, Germany, 3-5 November 1997). UNECE Convention on Long-Range Transboundary Air Pollution, Task Force on Mapping. Berlin: Umweltbundesamt (Federal Environment Agency), March 1998.

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