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Healing the Ozone Layer

The Montreal Protocol and the Lessons and Limits of a Global Governance Success Story

Frederike Albrecht and Charles F. Parker

Introduction

The Montreal Protocol—the international regime designed to protect the stratospheric ozone layer—has widely been hailed as the gold standard of global environmental governance and is one of the few examples showing that international institutional cooperative arrangements can successfully solve complex transnational problems. Although the stratospheric ozone layer still bears the impacts of ozone depleting substances (ODSs), the problem of ozone depletion is on its way to being solved and the 'ozone hole' has started healing due to the protocol. What explains this success and what can we learn from it in tackling other complex global environmental problems such as climate change?

The ozone layer is crucial to protecting the earth from the sun's ultraviolet radiation and is essential for absorbing ultraviolet B radiation, which, in large amounts, could seriously harm all plant, human, and animal life (Solomon 2008). In response to scientific evidence that man-made chemicals, chlorofluorocarbons (CFCs), posed a serious threat to stratospheric ozone the nations of the world first negotiated a framework convention, the 1985 Vienna Convention for the Protection of the Ozone Layer, and then, in response to new scientific evidence that confirmed the Antarctic 'ozone hole', added a regulatory agreement, the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The Montreal Protocol has dramatically reduced ozone-depleting chemicals and the ozone layer has been projected to recover by the end of the century, although some recently discovered challenges may demand further amendments.

In this chapter, we examine how the Montreal Protocol was designed and implemented in a way that has allowed it to successfully overcome a number of challenges that most international environmental regimes must face: how to attract sufficient participation, how to promote compliance and manage non-compliance, how to strengthen commitments over time, how to neutralize or co-opt potential 'veto players', how to make the costs of implementation affordable, how to

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leverage public opinion in support of the regime's goals, and, ultimately, how to promote the behavioural and policy changes needed to solve the problems and achieve the goals the regime was designed to address. We will conclude that while some of the reasons for the Montreal Protocol's success, such as access to available and affordable ODS substitutes, are not easy to replicate, there are many other elements of this story that can be utilized when thinking about how to design solutions to other transnational environmental problems.

Assessing the Montreal Protocol

There is a strong case that the Montreal Protocol has performed well on all four dimensions of policy assessment used in this volume. To date, the protocol has been a *programmatic* success in achieving its stated objectives and has made progress towards achieving its overarching goals, which were to protect human health and the environment against the adverse effects of activities that deplete the ozone layer. As a result of their protocol obligations, countries have phased out 98 per cent of ODS globally compared to 1986 levels (Ministry for the Environment and Stats NZ 2017: 46). In 2014, the US National Oceanic and Atmospheric Administration (NOAA) found that, after a peak in the year 2000, the atmospheric abundance of many ODSs had sunk under 1980 levels and predicted that the CFCs abundance would also fall below the levels of 1980 before 2050. This positive development can be connected directly to the Montreal Protocol (NOAA 2014). The worldwide production of ODSs has plummeted from some 1.2 million tons in 1986 to 80,000 tons in 2006 to being nearly eliminated in 2016 at 23,000 tons. Global ODS consumption has seen a similar trend dropping from 1.3 million tons in 1986 to 86,000 tons in 2006 and 22,000 tons in 2016 (UNEP Ozone Secretariat 2018). In fact, according to the Ozone Secretariat, in absence of the protocol, global CFC consumption would have been about 3 million tons in 2010 and would have reached 8 million tons in 2060, which would have resulted in a 50 per cent depletion of the ozone layer by 2035 (UNEP Ozone Secretariat 2018).

In sum, there is strong scientific evidence that the Montreal Protocol is indeed reaching the objectives it was designed to address. Achieving the objective to phase out ODSs is illustrative of its programmatic success. In addition, one of the goals of the policy, to close the 'ozone hole', is well on its way to be achieved. In 2018, researchers at NASA showed for the first time, through satellite observations, that the 'ozone hole' is recovering due to the reduction of chlorine from ODSs as a direct result of the Montreal Protocol (Strahan and Douglass 2018).

The second goal of the Montreal Protocol, improving public health by decreasing skin cancer risk, also has been deemed a success (Chipperfield et al. 2015). Although annual rates of new skin cancers in the USA and Europe are still increasing (CDC 2018; Boyle et al. 2004), we cannot attribute these numbers solely to the ozone layer because there are more factors than ozone depletion that affect skin cancer risk, e.g. the increased usage of tanning beds. Assessment models ran by scholars that took into account the difference between the ozone layer with and without the protocol's regulations, estimate that roughly 2 million cases of skin cancer will be prevented annually by the year 2030 due to the Montreal Protocol (van Dijk et al. 2013). This suggests that there is already a positive public health effect due to action taken under the protocol, and this effect should increase in the future. Thus, the Montreal Protocol appears to have delivered on its goal of reducing skin cancer risks and protecting human health, adding to its programmatic success.

This evidence illustrates that the Montreal Protocol is clearly making progress in achieving its objectives to protect the ozone layer through a phase-out of ODSs. In addition to the ODS reduction achievements, the Ozone Secretariat also points to a number of other important accomplishments, including high compliance rates, the successful utilization of scientific evidence as a basis for policy decisions, the delivery of health, climate, and environmental benefits, and utilization of the financial mechanisms to support developing countries in achieving their reduction obligations (UNEP Ozone Secretariat 2015).

Politically the protocol has succeeded in attracting the participation and support of a broad coalition of developed and developing countries. The strong global commitment to the protocol is underscored by the fact that it has achieved universal support and has been ratified by 197 parties. Being part of the protocol had positive effects on countries' reputation and political capital because the ozone depletion posed a risk for environment and public health that was shared globally. By implication, contributing to eliminating this risk would also provide globally shared environmental and public health benefits. The Montreal Protocol has also succeeded, after initial opposition, in winning the support of industry (Parson 1993: 46). By providing a stable and predictable framework that allowed industry to transition away from ODSs to newer, less harmful, and affordable substitutes the protocol has been good for industry and the environment (Haq et al. 2001: 134–5; Rae 2012).

In *process* terms, the structure and management of negotiations contributed to reaching a strong and innovative international regulatory agreement. The flexible design, system for implementation, and compliance procedures of the Montreal Protocol have created effective processes that have contributed to its success in attracting universal participation, increasing its ambition over time, and achieving stated objectives. The flexible design that operates according to the precautionary principle resulted in setting stringent ODS abatement targets before the science was conclusive and allowed ambition to be increased once the science indicated that stronger action was needed. The inclusion of trade sanctions against non-parties and the provision of financial incentives to developing countries encouraged countries to join the protocol and helped to rather quickly achieve full participation.

The protocol ensured that all parties had the financial and practical possibility to implement its required provisions, such as enacting national controls, by granting a certain degree of freedom during the process and offering financial help to developing countries. Hence, the process could be perceived by all participants as sufficiently fair and legitimate to encourage participation and compliance. The protocol's non-compliance procedures have made it possible to utilize both positive incentives, such as funding and technical assistance, as well as the threat to cut off funding or enact sanctions to encourage adherence with its obligations. Not only have the initially agreed upon ODSs been successfully phased out, the protocol, aided by provisions for regular meetings and scheduled expert assessments and treaty reviews, has also undergone several amendments which added new substances to be phased out over time. The implementation of these amendments is another dimension of the procedural success of the policy.

In terms of *endurance*, the protocol has repeatedly succeeded in adapting and updating its objectives and instruments. To remain effective over time, environmental regimes must be able to adjust and adapt to changing circumstances that occur after the initial agreement. The Montreal Protocol has proven to be adept at responding to new information and challenges by strengthening its provisions (Young 2011). Annual meetings combined with periodic scientific assessments and treaty reviews have facilitated a process that has allowed the Montreal Protocol to update its targets and increase its ambition while maintaining political support among its members. The protocol's Meeting of the Parties (MOP) has acted repeatedly to accelerate phase-out schedules for individual ODSs already covered and by adding additional chemicals to the list of those covered under the terms of the agreement as soon as more ambitious goals became economically and politically feasible (Andersen and Sarma 2002; Parson 2003). Its control provisions were strengthened through five amendments, which accelerated phase-outs and added additional substances, adopted in London (1990), Copenhagen (1992), Montreal (1997), Beijing (1999), and Kigali (2016).

Adding new families of chemicals to the list of those scheduled for phase-out under the Montreal Protocol requires a decision on the part of the MOP and acceptance on the part of member states. This stringent requirement has not been an obstacle to strengthening commitments. Moreover, the initial success of the agreement appears to have shaped virtuous cycles that have lowered the cost of compliance through institutionalized deliberation and adjustment routines during the MOPs. The Montreal Protocol now covers some 100 hazardous chemicals. Interestingly, some of the ODSs are greenhouse gases (GHG) that also contribute to climate change and the implementation of and compliance to the Montreal Protocol was so successful that research found the Montreal Protocol to have had more benefits for climate change mitigation than the Kyoto

Protocol (Velders et al. 2007). It has been estimated, for example, that the total climate change mitigation through GHG reduction provided by the Montreal Protocol was ten to twenty times more effective than the reduction from the Kyoto Protocol's first commitment period (Xu et al. 2013). It has also been claimed that a reduction of hydrofluorocarbons (HFCs) through the Montreal Protocol could prevent up to 0.5°C temperature increase by 2100 through substantial GHG emissions reduction (Zaelke et al. 2018). HFCs, which had not been addressed in the protocol previously, have been taken up under the latest developments of the MOP. An amendment to phase down HFCs was adopted in 2016 in Kigali, Rwanda (Bergeson 2017). The ratification of the Kigali Amendment by the member states is currently ongoing and it will enter into force in 2019 (European Commission 2017). By August 2018, 42 out of 197 member states had accepted or ratified the amendment.

The Challenge: Healing and Protecting a Global Open Access Resource

Solving vexing transnational problems such as stratospheric ozone depletion requires states to agree to the nature of the problem, negotiate an agreement to solve the problem, and then make the agreement work. Past experience and research on international cooperation and efficacy of global institutions demonstrates this is difficult to do effectively for a variety of reasons (Miles et al. 2002; Breitmeier et al. 2006; Young 2011). There is the sheer complexity of many transnational issues. Multilateral negotiations on issues such as ozone depletion or climate change often involve over 190 countries and touch on a wide range of issues in multiple policy areas. And then there is the difficulty of agreeing to a negotiating agenda (Young 1991): even when most states agree that an issue is important, they often have conflicting views on how the problem should be framed and which solutions should be pursued. Also, there are the various configurations of interests among the parties and the challenges this presents to burden sharing. Determining what is fair can be difficult to agree on and there are often multiple views regarding what is equitable (Keohane and Oppenheimer 2016). Veto players and public opinion can be complicating factors to reaching an agreement and then making it work once agreed. The difficulties of cooperation are also compounded by multiple levels of uncertainty. Actors don't know at the outset whether proposed solutions will work, whether the costs of cooperation will be worth the benefits, nor whether other states will actually honour the commitments they make. Finally, once an agreement is reached, if it is to succeed it must attract a sufficient number of key states to participate, states must honour the commitments they have made and comply with the agreement's rules (Parker 2001, 2013).

The degradation of the ozone layer presented a classic common pool resource problem. Healing and protecting it from further degradation would only be successful if these underlying collective action problems could be solved on a global level: all large-scale producers and consumers of ODSs (namely CFCs and halons) needed to commit to a global cooperative solution. The atmosphere is a resource that all actors, nation-states and industries have open access to. However, to the extent it is used, i.e. through the emission of ODSs, the resource is affected and degrades continuously. In the absence of a comprehensive governance arrangement it was impossible to exclude actors from harming the ozone layer through emissions of ODSs negatively affecting global society (Epstein et al. 2014).

Hardin (1968) famously claimed that common pool resources of this type will always be overused and ultimately destroyed due to rivalry in consumption and the non-excludability of users. He predicted that the rational interests of involved actors to maximize their own benefits will increase the use of the resource to its destruction. To this day researchers remain sceptical as to whether the international society is capable of sidestepping this tragedy of the commons in relation to global open access resources, such as the earth's atmosphere (Araral 2013).

In the case of the ozone layer, the resource's very attributes complicate the situation and the search for a workable solution (Agrawal 2003; Epstein et al. 2013). First, the ozone layer is of global importance but effectively invisible. It is also highly mobile, implying that the emission of ODSs does not result in direct local consequences while also making it difficult for involved parties to see clear benefits for any efforts to protect and heal the ozone layer. In addition, because it takes a long time for the ozone layer to recover from the effects of ODSs, the value of potential, but distant, benefits may not motivate participating actors that desire more immediate gains (Epstein et al. 2014). While these resource characteristics make it potentially more difficult for countries to become motivated to engage in global cooperation and reduce emissions, they also highlight the fact that only a truly global solution (without free riders) can solve the problem, as shifting emissions to other, non-participating countries would undermine the effectiveness of any non-comprehensive regime.

The main actors involved in the process of finding a governance arrangement that would restrict the emission of ODSs for the protection of the ozone layer included nation-states and international organizations including NGOs, the European Economic Community (EEC), and, since 1972, the United Nations Environmental Programme, which went on to host many meetings and initiatives in this area. The industrial sector, notably in the form of ODS producers, also participated in the negotiations. The interests of these actors diverged widely. Some aimed for an international agreement, others felt national regulations alone would be sufficient, and some rejected the proposition that a policy to protect the ozone layer was needed at all.

Different clusters of nation-states were influential in shaping, or resisting, the negotiations to address ozone depletion. The lead states in the process, Canada, Finland, Norway, Sweden, and the United States, eventually formed a coalition to push aggressively for a global policy to reduce ODSs (Wettestad 2002). Many of these countries implemented national regulations comparatively early on, partly in collaboration with their industrial sectors. In the United States, for example, domestic politics, environmental concerns, and pressure from a major lawsuit had put ozone protection on the political agenda, which motivated American negotiators to push for a strong global agreement (Parson 1993).

Due to the economic importance of ODS chemicals, there was also a number of countries that opposed a control regime. Producer countries, represented by the European Economic Community (whose position was controlled by France, Italy, and the UK), Japan, and the Soviet Union formed one potential veto coalition. Another potential veto coalition was composed of several large developing countries, such as Brazil, China, India, and Indonesia, which wanted the option to produce ODSs in the future. Crafting an agreement that would be supported by all these factions was a tall order. UNEP and its Executive Director, Mostafa Tolba, played a central role in overcoming these obstacles by repeatedly organizing international meetings and providing a forum for negotiations. As we will discuss, Tolba's leadership was instrumental in helping the various countries reach consensus through informal deliberations in the final stages of negotiations (Andersen and Sarma 2002).

The Road to Montreal

The Role of Scientific Evidence

Concerns about the potential depletion of the ozone layer by human activities were first raised in the early 1970s in relation to supersonic transport. Although initial scientific studies on stratospheric chlorine in Europe and the United States did not arrive at definitive conclusions, they attracted public attention and a policy debate ensued over ozone. One of the controversies and disagreements between actors regarded how much scientific certainty was needed to justify policy action to protect the ozone layer (Parson 2003). In the following years, attention shifted from supersonic transport to the role of CFCs and their potential negative impact on the ozone layer. Early studies, such as Molina and Rowland's (1974) discovery of the effect of ODSs on the ozone layer, found that ozone was negatively affected by CFCs in the stratosphere, but did not quantify or predict the loss in ozone yet. This research prompted a rapid increase in scientific attention and spurred policy responses in Canada, the European Economic Community, Sweden, and the United States to restrict the use of CFCs, mainly in aerosols (Andersen and Sarma 2002; Parson 2003). Between 1978 and the final negotiations that led to the Montreal Protocol, the scientific evidence and predictions of ozone depletion varied significantly. Predicted ozone layer depletion ranged from 15 per cent in 1978 to 3–5 per cent in 1982.

Scientific knowledge can be an important factor in informing policy-makers about the severity of an emerging problem and contributing the needed pressure to overcome collective action problems (Epstein et al. 2014). However, before a firm scientific consensus is reached, users of a common pool resource will often resist regulation and offer competing interpretations of uncertain knowledge (Stern 2011). This was certainly the case in the debate over ozone protection and made the establishment of international controls extremely difficult. The variation in scientific estimates regarding potential depletion allowed several countries to reject the necessity of an international policy regulating ODS use. For example, the United Kingdom was sceptical whether regulation over a longer period would be necessary as ozone layer depletion estimates had been reduced between 1978 and 1982. Japan also repeatedly rejected any proposal to protect the ozone layer until further scientific evidence had been compiled (Andersen and Sarma 2002).

A breakthrough in the public debate and in the negotiations was achieved when research provided additional hard evidence that ozone depletion was a threat to the environment and public health. In 1985, the scientific discovery of the so-called ‘ozone hole’ demonstrated that the loss of ozone was much larger than could be accounted for with existing scientific models (Farman et al. 1985; Solomon et al. 1986). This discovery served as a dramatic focusing event and the resulting increase in global public attention to the problem of ozone depletion created a sense of urgency about the need for a robust global policy solution.

Support among the General Public and Industry

In addition to key nation-states and environmental NGOs, the coalition that formed around what would eventually become the Montreal Protocol also included other actors, such as specific industrial producers of ODSs, which helped to create broad public legitimacy for the agreement. In the case of ozone depletion, most of the industrial sector opposed CFC controls initially, but after 1986 industries themselves started to call for controls. When one of the leading CFC producers, the US chemical giant DuPont (25 per cent global market share in the mid-1980s), decided to support the phasing out of many chlorofluorocarbons and halons this made a big difference in reaching an agreement and to later efforts to accelerate phase-out schedules under the protocol (Parson 1993).

In addition, increasing scientific evidence and the discovery of the ‘ozone hole’ created an international public discourse on the issue and how to address it. Already in the late 1970s, researchers provided evidence that ‘a decline of ozone by 1 per cent would ultimately lead to a 4 per cent increase in skin cancer incidence' (Andersen and Sarma 2002: 49). In combination with the detection of a hole in the ozone layer, the connection between a damaged ozone layer and increased risk for skin cancer sparked international debate. Ozone depletion became framed as a matter of public health (Armstrong 1994; Martens 1998). Fears for a dramatic rise in the incidence of melanomas and glaucoma connected to increased exposure to solar radiation as a result of the thinning of the ozone layer were an important factor that created public support for an agreement to protect and heal the ozone layer. Ultimately, the damaged ozone layer became a 'hot crisis' (Ungar 1998: 510) in the media and among the general public. This upped the ante for governments. Signing up to the protocol morphed from a political liability (opposed by big corporate interests) into a political asset (now supported by important segments of industry, research, the healthcare sector, and the public at large), thus lowering the threshold for doing so and locking in the commitment once it had been made (Patashnik 2008).

The Protocol Design and Negotiation Process

Sweden, Finland, and Norway took a prominent role in the early negotiations and drafted the Nordic Proposal that aimed at eliminating the use of certain CFCs in non-essential aerosols in 1983. This first proposal was the draft which would be developed into the Montreal Protocol over the following four years. The proposal met with both support (Denmark, United States, and Australia) and opposition (Japan and United Kingdom). In 1985, twenty countries and the EEC signed the Vienna Convention, the first international agreement on the protection of the ozone layer. But the framework refrained from imposing any reduction obligations on the parties and instead served the purpose of providing monitoring and data exchanges regarding the ozone layer (Skjaerseth 1992). Article 2b laid out future efforts to be taken by parties of the convention, which consisted of cooperation to achieve legislative and administrative measures to protect and heal the ozone layer (Andersen and Sarma 2002).

In the meantime, the Nordic countries had formed the Toronto Group together with Canada and the United States to draft a new proposal which suggested a reduction of the total CFC use in non-essential aerosols. The proposal was met with criticism from the EEC, which countered the draft with a suggestion to not restrict regulations on aerosols and instead regulate the total use and production of specific CFCs. A debate emerged between the EEC and the Toronto Group on which measures were appropriate, during which both parties accused each other's proposals of failing to solve the actual problem of ozone depletion. By March 1985, the situation around these different approaches had not improved. Negotiations on the proposal had not progressed significantly and '[d]espite many attempts to take at least a first step to control CFCs, the governments failed to agree on anything concrete' (Andersen and Sarma 2002: 64).

The impasse had to be broken. The various camps jockeyed for position and in the following two years, a number of additional proposals were drafted by the EEC, Canada, the United States, and the Soviet Union. The EEC advocated cutting the total production of CFCs by 20 per cent. Canada suggested a global ODS emissions limit that would be allocated proportionally to countries depending on their population and gross national product. The United States suggested a freeze on consumption instead of production of CFCs, followed by a phased reduction of 95 per cent (Parson 1993). This proposal was supported by the Nordic countries and Switzerland. The Soviet Union suggested controlling the production of certain CFCs and freezing CFC production no earlier than in the year 2000 (Andersen and Sarma 2002).

A breakthrough in the negotiations was reached in 1987. One of the main drivers to reach a consensus was Mostafa Tolba, the then Executive Director of UNEP. He was largely responsible for a proposal draft in 1987 that summarized control measures without demanding commitment from parties. Tolba emphasized the importance of informal consultations, which he used to work up a draft proposal, as he found that during informal discussions representatives were more willing to rethink the positions of their governments. Emerging interpersonal respect and trust among representatives over time also made negotiations easier (Andersen and Sarma 2002).

Following Tolba's draft proposal, more than fifty countries, multiple industry organizations, environmental NGOs, the UN, and a host of other actors took part in the final, intense, negotiations in 1987 which concluded with an agreement. Compromises were reached, for example, to make compliance with the agreement easier for countries where future CFC production had already been planned, such as the Soviet Union, Japan, and Luxembourg. Five CFCs and three halons fell under the agreement in the Montreal Protocol. The decision to focus on the production and consumption of chemicals instead of their use in different sectors made it possible for actors such as Japan to find alternatives for their most commonly used ODSs while reducing other gases.

The Montreal Protocol sought to achieve a reduction of both production and consumption by 50 per cent of the aforementioned ODSs. In 1990, this objective was upgraded to achieving a total phase-out of these ODSs by the year 2000. The protocol furthermore offered special conditions to developing countries in order to not harm progress in their development. The repeated international negotiations, debates on various drafts for a proposal, and the compromises in the final agreement to accommodate the specific needs and interests of particular countries can be assessed as a successful policy process (Andersen and Sarma 2002). One year after the protocol's entry in force, in 1990, it had been signed by fifty-eight parties that accounted for 90 per cent of the global CFC and halon production and consumption. Over time, additional countries joined and at present the Montreal Protocol has achieved the universal ratification of 197 parties.

A crucial aspect of the Montreal Protocol was its success in overcoming collective action problems. Widespread participation was vital, because if the agreement was to work no substantial consumers or producers of ODSs could remain outside the agreement. To prevent the relocation of production facilities to countries that did not join the protocol and to create an incentive for participation, the deal included trade provisions. These provisions restricted trade in CFCs and ODSs with non-parties (Wettestad 2002). There was in-built momentum for change (Patashnik 2008): once the main producing countries joined the protocol, it was only a matter of time before all countries had to join or risk not having access to key chemicals. In 1990, the parties also decided to establish a Multilateral Fund to encourage developing countries to join the process by providing them with financial and technical support to phase out their use of ODSs (Andersen and Sarma 2002).

How the Protocol Gained Its Strength

The Montreal Protocol would not be a true success story without key elements that facilitated its implementation and earned it widespread legitimacy for its policy obligations. First, universal ratification has prevented free riding. Second, high levels of compliance with the phase-out obligations have been achieved by virtually all member states. ODSs (CFCs, halons, carbon tetrachloride, methyl chloroform, and clorobromomethane) reached a 98 per cent phase-out by 2010 (which was the scheduled goal); the remaining 2 per cent are hydrochlorofluorocarbons (HCFCs). For HCFCs, the current goal is to achieve phase-out by 2020, which is an acceleration of the previous deadline of 2030 (UNEP Ozone Secretariat 2015).

Coping with Compliance Challenges and Costs

Compliance has been described as the Achilles' heel of international environmental regimes (Young 2011). Those who are opposed to the creation of a regime, or participation in one, often cite the high costs involved with implementation to justify their opposition. Technological innovation can often provide a solution. Once a regime is in place and those actors involved in implementation begin to give attention to how to do so efficiently, innovations can emerge that make compliance less costly than initially expected. The ozone regime is a good example of this (Haq et al. 2001). Producers found affordable alternatives for many ODSs and these replacements sometimes turned out to be less expensive than the original chemicals. The efficiencies that were realized in the initial implementation of the protocol have paved the way to making it easier to strengthen commitments, even those that were the subject of contentious bargaining at the outset.

Research on environmental cooperation has emphasized the importance of monitoring and enforcement mechanisms as essential attributes to promote compliance with agreements that govern common pool resources, such as the atmosphere (Ostrom 1990; Stern 2011). In addition, procedures to facilitate communication and deliberation among the partners of common pool resource governance arrangements increase the likelihood of overcoming collective action problems and preventing the free riding of actors who might attempt to use the resource without complying with the agreed upon rules (Ostrom 1990, 2010). These basic assumptions can also be found in relation to research on international regimes, which has highlighted the importance of an institutional design that includes both management and enforcement features to help encourage compliance (Parker 2001).

The 'management' approach has stressed the importance of transparency, dialogue among the agreement's parties, dispute resolution procedures, and technical and financial assistance to promote compliance. The 'enforcement' approach has stressed monitoring activities in conjunction with potent sanctions. Overall, the management approach has been found to maximize compliance better in some settings than enforcement, even in regulatory regimes (Chayes and Chayes 1995; Young 2011). Ideally, to get the best of both worlds, multilateral agreements should be equipped with mechanisms that provide incentives (resource carrots) for compliance while applying strong sanctions (costly sticks) for non-compliance (Parker 2011).

A study of the Montreal Protocol's non-compliance procedures found that its implementation committee was most effective when the management and enforcement approaches to compliance were blended (Victor 1998). 'Management avoids the most severe and unproductive antagonism, but the credible threat of tougher actions, including sanctions, helps ensure cooperation, especially when dealing with parties who are unswayed by management alone' (Victor 1998: 139). Thus, the mechanisms utilized to promote compliance with the agreement's obligations have been effective and illustrate further why the protocol is both a procedural and programmatic success.

Assistance for Developing Countries

Making financial assistance available to member states that agreed to strengthen their commitments under the Montreal Protocol was a crucial factor that facilitated the commitment and political support of developing countries. In the case of the Montreal Protocol, financial arrangements are available to provide assistance to those willing to strengthen their commitments. In 1990, an amendment was added, which created the Montreal Protocol Multilateral Fund as a way to help developing countries (known as Art. 5 parties) to shift to non-ODSs or to pursue development without relying on ODSs. Thus, the regime fairly distributed costs and prevented developing countries being forced to act as free riders due to restricted compliance capacity. It has also increased the inclusion and participation of partners, facilitating the maintenance of the maximum winning coalitions that are generally associated with successful international environmental regimes (Young 2011).

Distributed Leadership

The effective exercise of different modes of leadership (Parker and Karlsson 2014), including scientific, political, and entrepreneurial leadership, from a number of key actors has been a crucial determinant in the Montreal Protocol's success. Scientific leadership has been important in pinpointing the effect of ODSs on the stratosphere and in identifying the core environmental and public health issues that were at stake. Authoritative scientific reports on these threats have repeatedly provided an impetus for action for negotiators and the parties. For example, reports exposing the probable health impacts of the loss of stratospheric ozone that came out during the mid-1980s had a strong effect on the provisions that were included in the 1987 Montreal Protocol and, as new scientific evidence became available, on the subsequent amendments to the agreement that accelerated the phase-out schedules and added additional ODSs for elimination.

Political leadership was taken by a diverse group of actors at different stages. The Nordic countries, led by Sweden, were particularly influential in launching the process to negotiate an international agreement to protect the ozone layer (Parson 1993: 37). Throughout the process, the Nordics, along with like-minded countries such as Canada, New Zealand, and Switzerland, were continuously involved in drafting proposals and coordinating diplomatic efforts to reach a deal (Wettestad 2002: 160–1). The United States was also an important leader. In the early stages, the United States primarily provided intellectual and scientific leadership on the issue of ozone depletion. Then, starting in 1986, after domestic decisions to reduce CFC use, the United States exerted its diplomatic muscle by taking a strong leadership role in the negotiations (Parson 1993; Wettestad 2002).

Finally, entrepreneurial leadership by UNEP's leader Tolba, as we have discussed above, proved pivotal in achieving agreement on the Montreal Protocol. In the post-creation phase, the Ozone Secretariat has assumed the entrepreneurial leadership mantle and has skilfully worked to ensure the successful implementation of the agreement and to help facilitate adjustments that have increased the agreement's scope and ambition. It has done so by organizing informal and formal meetings of the parties, proposing draft language for treaty amendments, forming review panels, and involving itself in reporting and compliance issues (Wettestad 2002: 162). In sum, the Ozone Secretariat's role has contributed to the creation of positive feedback loops that have facilitated repeated adjustments in the policy demands of the protocol in a manner that enabled fair access for all parties to participate and influence the process, while at the same time helping the parties deliver on their obligations.

Lessons Learned and Future Challenges

Social science research on collective action problems and common pool resources in the 1960s and 1970s was largely occupied with pointing out the difficulty, and even impossibility, of cooperation among diverse groups of actors and predicted a tragic fate for public access resources. The negotiations, the agreement, and the implementation of the Montreal Protocol nevertheless demonstrates that it is feasible to overcome collective action problems (e.g. Hardin 1968; Olson 1971)—even on a global scale, even when the resources in question are difficult to understand, and even if the measurable effects of policies enacted to address the problem have relatively long time horizons before their benefits are apparent.

The protocol effectively addresses the governance of the atmosphere as a global public access resource. The international negotiations surrounding climate change and greenhouse gas emissions must also address the governance of the atmosphere, and the Montreal Protocol provides an instructive case in point on how to overcome collective action problems, bring together heterogeneous actors to reach a common agreement, prevent free riding, and adjust to new scientific realities.

There are factors, however, that limit the Montreal Protocol's applicability to other environmental challenges such as confronting climate change. First, the reduction of ODSs was comparatively simple; it involved controlling a set of specific industrial gases for which substitutes were available and the alternatives, which were quickly developed, also proved to be cheaper than the harmful substances they replaced. Reducing greenhouse gas emissions to address the problem of climate change is considerably more complex and will require more far-reaching societal transitions involving the energy, transport, and agricultural sectors, among others. Moreover, each sector contains powerful veto actors, such as the fossil fuel industry. Second, key countries with major ODS producing industries actively supported an agreement and provided leadership. In contrast, the international effort to address climate change has lacked leaders that are widely seen to be acting for the common good to solve the problem of global warming (Parker et al. 2015). Third, with regard to the problem of stratospheric ozone depletion, the issues of impact, fairness, and equity were clear and fairly easy to address. The effects of ozone depletion are spread across the globe and all countries are affected. Moreover, the normal North–South divide between the developed and developing world, which we see, for example, with climate change, has not been at play to the same extent here. The developed world is in just as much immediate risk due to ozone depletion and the Multilateral Ozone Fund can provide the capacity-building help and funding that keeps the costs of involvement for developing countries affordable (Wettestad 2002).

That said, there are lessons that are potentially relevant for other transnational environmental challenges, even ones for which we do not have simple technological solutions. An interesting aspect of the Montreal Protocol success story is how the accumulation of scientific evidence served as a catalyst for cooperation both for reaching a deal and for increasing ambition and strengthening commitments over time. It illustrates the importance and potential impact of scientific knowledge for forging collective solutions to environmental challenges. Regarding implementation, the Montreal Protocol provides good examples of fruitful strategies to facilitate compliance and build confidence through a calibrated combination of management and enforcement approaches. Moreover, although it will be far more difficult to accomplish for the reasons laid out above, climate change will ultimately need to be solved by finding substitutes for fossil fuels and providing financial help for the least able countries. This will not be easy and time will tell if the Paris Agreement and the Green Climate Fund are up to this epic challenge.

How then should we assess the international effort to address the challenge of ozone depletion? Has the Montreal Protocol saved the ozone layer for all time? Until recently, assessments of ozone depletion were very optimistic about healing the entire ozone layer. The 2014 scientific assessment identified a stable ozone column since the year 2000 and predicted a full recovery of the ozone layer by the end of the century (WMO et al. 2014). Scholars also found clear evidence that the depletion of the ozone layer would have been worse without the Montreal Protocol (Chipperfield et al. 2015). In addition, the latest evidence shows that the protocol has been successful in starting the healing process needed to repair the ozone hole (Strahan and Douglass 2018).

However, recent research has identified that the ozone column is declining again between the latitudes 60°N and 60°S, i.e. most of the world, where potential harm due to more intense UV radiation may be dramatic (Ball et al. 2018). Explanations range from an alteration of atmospheric circulation through climate change that shifts ozone, to negative effects of very short-lived chemicals found in, e.g. solvents and degreasing agents, which are not addressed by the Montreal Protocol (Hossaini et al. 2017; Ball et al. 2018). One of these damaging chemicals is even used to produce ODS replacements (Hossaini et al. 2017). These results, and the accompanying scientific uncertainty, require further investigation and raise questions concerning whether the overall impressive achievements of the protocol, so far, will be sufficient to repair the ozone layer as projected.

To date, the Montreal Protocol has been a programmatic, political, and procedural success that has, moreover, endured over time. It has achieved the specific objectives it set for itself by phasing out many harmful substances and it has contributed to the closing of the Antarctic ozone hole. However, although it clearly has had positive impacts on public health and in addressing ozone depletion, a complete recovery of the ozone layer has yet to be secured. Nonetheless, the Montreal Protocol's successful track record of adjusting ambition in light of new scientific evidence, if it continues, suggests that the prospect of eventually healing the ozone layer is still within reach.

Additional version of this case

The case study outlined in this chapter is accompanied by a corresponding case study from the Centre for Public Impact's (CPI) Public Impact Observatory—an international repository of public policies assessed for their impact using CPI's Public Impact Fundamentals framework. CPI's framework provides a way for those who work in or with government to assess public policies, to understand why they were successful, so key lessons can be drawn out for future policy work. The case can be easily located in the CPI repository at www.centreforpublicimpact.org/observatory.

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