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The evolution of Rhine river governance: historical lessons for modern transboundary water management

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Abstract Transboundary rivers pose significant governing challenges to state actors, as riparian stakeholders struggle to balance their own interests in a critical resource against those of their neighbors. To that end, a case study of Europe's Rhine River is illustrative, as it provides a strong historical example of shared water management. Indeed, the Rhine experience suggests at least two universal lessons that modern riparian actors the world over would do well to consider when balancing shared riverine interests. First, that transboundary water cooperation is supported by a shared historical legacy of water governance, suggesting that, if a governing regime does not yet exist, riparian actors should purposefully create one in anticipation of future coordination issues. Second, the case of the Rhine demonstrates that an acute environmental crisis is not a necessary condition for intensive shared riverine governance, and instead, it is extant historical collaboration that leads to later effective crisis coordination.

Keywords Rhine · Environmental policy · Environmental governance · Transboundary water sources

Abbreviations

EU	European Union
ICPR	International Commission on the Protection of the Rhine
IWT	International water tribunal
IRBD	International river basin district
RAP	Rhine Action Plan
RBMP	River basin management plan
WFD	Water Framework Directive

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On November 1, 1986, the Sandoz A.G. warehouse caught fire in Schweizerhalle, near Basel, Switzerland. Four days before, the Swiss Fire Prevention Service had inspected the Sandoz A.G. building and "found its safety measures adequate," but that inspection was not enough to prevent the November 1 fire (Tuohy 1986). The sudden fire event proved devastating to the adjacent Rhine River. Due to the Sandoz fire, the run-off from the firefighters' extinguishing water flowed straight into the Rhine, and as a result, approximately 30 tons of highly toxic pesticides entered the river and killed almost all of the river's fish and plant life as far downstream as Koblenz, a distance of approximately 400 km. The high level of river pesticides also required that the public along the banks of the Rhine, all the way to the Netherlands (almost 1000 km from the accident site), refrain from acquiring drinking water from the river for several days after the accident (Tuohy 1986).

To add insult to injury, in the few weeks directly following the Sandoz fire and chemical spill, the Ciba-Geigy plant, which was just a few miles away from the burned-out Sandoz building, accidentally released a chemical gas cloud, and then a few days later, Ciba-Geigy inadvertently leaked weed-killer into the Rhine. All of these incidents were then followed by an accidental leak of mercury compounds into the Rhine at the Sandoz plant (Netter 1986). Additionally, these events all transpired in an atmosphere of extant "chemical fear," as they occurred just months after the Chernobyl nuclear accident in the Soviet Union. As such, local officials and the public began to call for more regulation, and in the wake of these chemical incidents, a Swiss official stated, "There is now more fear than there was before…It may not be so dangerous, but the people are already highly sensitized. This just keeps going on and we must stop it" (Netter 1986, para. 9).

The consequences of Sandoz and its related chemical crises shocked the Western European public and mobilized it to apply pressure to its respective governments to clean up their shared resource of the Rhine. It is important to note, however, that such improvement did not occur in a governance vacuum or simply as a result of an acute environmental crisis. Instead, when riverine stakeholders called for improvements to Rhine pollution after Sandoz, those improvements built upon a strong extant network of shared river governance. Indeed, it is the strength of this extant network that this analysis explores, as it asks whether the Rhine's historical governance experiences provide lessons for transboundary water stakeholders around the world. How can resources that cross the borders of multiple countries, and whose health and viability are affected by the behavior of government and individuals inside those countries, be managed successfully based on a traditional model of international governance that emphasizes state sovereignty? Modern policymakers must address this question because "where effective governance systems are in place, humans can interact with nature in such a way as to avoid problems…but where such systems are underdeveloped or dysfunctional, the costs both to individuals and to society at large can become severe" (Young 2013, p. 1).

Why the Rhine river?

The Rhine River is one of Europe's most vitally important water sources, as it provides power, drinking water, irrigation, and recreation for approximately 50 million people (ICPR 2001, p. 2). Most importantly, in terms of this analysis, the Rhine stands as a model of historical transboundary water management, and as such, analyzing the evolution of the Rhine's governing regimes may hold lessons for other countries by providing a potential answer to the vexing water collaboration puzzle. To draw out those lessons, this paper

applies the international relations literature on regime creation, and environmental regime creation in particular, to evaluate the evolutionary history of the Rhine's governing regimes and offer potential insights and policy prescriptions into river management across the globe. This methodological approach is somewhat distinctive, as it combines historical analysis with an applied policy component in an attempt to unite a descriptive and prescriptive approach to river management. Indeed, much of the relevant literature on international river management "is almost entirely descriptive and focuses on management practices on individual rivers," or on "lessons learned" from previous experience, while alternative scholarly work tends to be "predominantly prescriptive," offering proposals for more effective future water management (Bernauer 2002, p. 2).

Ultimately, the historical case study evidence provided by the Rhine speaks to three separate evolutions in terms of Rhine governance, and the results of those evolutions hold two potential policy prescriptions for riverine transboundary water stakeholders across global contexts. First, over time, the Rhine itself evolved from a meandering stream to a highly engineered canal. Second, the river's stakeholders initially shared dilemmas of common interest centered on economic vitality, which eventually transformed into dilemmas of common aversion as the Rhine's pollution worsened because of increased economic activity and reengineering. Third, the governance regimes created to handle the concomitant dilemmas of common interest and aversion saw their own evolutions from more spontaneous governance arrangements, to more formalized regimes, which finally evolved to include a level of imposition as a way to ensure stakeholder accountability.

One must recognize, of course, that the Rhine's governance experience is unique because the river itself, like all waterways, has a singular history that is unlikely to be duplicated directly in other regions of the world. With that caveat, though, this paper proposes that there are at least two lessons from the Rhine experience that contain broad applicability in a variety of geopolitical contexts. In the end, the evolution of the Rhine's historical governance regimes suggests that modern transboundary water cooperation, though incredibly difficult at times, is aided by a *shared historical legacy of water governance*. In international relations terms, this idea speaks to the "shadow of the future" or the idea the idea that actors cooperate today because they have an expectation that they will need to work together again within the confines of a shared regime or institution (Oye 1986, p. 12). This finding indicates that, if a riverine governing regime does not yet exist, riparian actors should purposefully create one, in anticipation of future coordination and collaboration issues. Second, and in opposition to the relevant literature on the subject, the case of the Rhine demonstrates that an acute environmental crisis, or a dilemma of common aversion, is not a necessary condition for effective shared riverine governance. In other words, *collaboration does not require a crisis*, but the historical networks established early on to address dilemmas of common interest make the transition to coordination over dilemmas of common aversion a more efficient process. Again, this idea speaks to the need for stakeholders and policymakers to work toward creating collaborative governance regimes now, rather than waiting for an acute environmental emergency to arise.

A review of the literature

Prior to assessing the specific case of the Rhine, an appraisal of the salient literature on regimes is in order. Regimes use the convergence of actor expectations to "exert pressure on their members to act in conformity with some clear-cut social or collective goal," while

they also link actors together through rules or conventions that "may or may not be formally articulated" (Young 1989, pp. 24, 13). Some theorists even argue that regimes exist wherever one finds consistent behavior within any cohesive issue-area in international relations (Stein 1982, pp. 300–301). Most broadly, one may define regimes as "sets of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area" (Krasner 1982, p. 186).

The facilitation of uniform expectations stands as just one benefit of an international regime. Regimes may also make it easier for states to improve their reputations within the international system because they help to "reinforce and institutionalize" reciprocity, rather than serving as its substitute (Axelrod and Keohane 1985, p. 250). Regimes may also promote future cooperation by sanctioning states that violate the stated goals of the regime, and in this way, regime constructions "delegitimize defection…and make it more costly" (Keohane 1982, p. 338). Finally, regimes reduce transaction costs within the interstate system, while they may also help to develop and perpetuate new norms or standards of behavior (Keohane 1982, p. 354).

Thus, regimes are developed in part because actors in world politics believe that such measures will allow them to construct mutually beneficial agreements that would otherwise be very difficult to create, but not all regimes emerge under identical formative circumstances (Keohane 1982, p. 334). Some regimes are spontaneous creations, and such regimes do not require "conscious coordination" among actors or clear consent of regime participants (Young 1989, pp. 84–85). Conversely, a regime may be explicitly negotiated among its members, and formal accounting of results and conscious agreement on the part of actors characterize this category of regime (Young 1989, p. 87). Imposed regimes constitute a third regime type. The notion of imposed regimes harkens back to the idea of hegemonic dominance, as powerful international actors establish the "rules of the game" and force others to conform to these arrangements through a combination of "coercion, cooptation, and the manipulation of incentives" (Young 1989, p. 88).

No matter whether they are of an intra- or interstate variety, spontaneous, negotiated, and imposed regimes all help states to solve dilemmas of both common interests and common aversion. For its part, a dilemma of common interests occurs "when independent decision-making leads to equilibrium outcomes that are Pareto-deficient" (Stein 1982, p. 304). As the famous Prisoner's Dilemma game illustrates, this simply means that all actors involved prefer a solution that is suboptimal. To rectify a dilemma of common interests, then, states agree to coerce one another in order to guarantee that none of their contemporaries will "defec[t] from the pact and refus[e] to cooperate" (Stein 1982, p. 304). In this way, states involved in a regime can avoid reaching a suboptimal solution in a given issue-area, while ensuring a particular and preferred outcome. Alternatively, regimes also provide solutions to dilemmas of common aversions. In this type of dilemma, the problem is not with finding an optimal outcome for the group. Instead, all actors involved wish to avoid one specific outcome (Stein 1982, p. 309). Both of these regime types, then, differ in their requirements, as dilemmas of common interests require collaboration among actors, while dilemmas of common aversion require actor coordination (Stein 1982, p. 312).

In terms of environmental regimes specifically, they are usually governed by rules that attempt to promote fair allocation, ecological integrity, and force all actors to collaboratively manage a natural resource, such as a transboundary waterway. The literature identifies spontaneous regimes as much more successful than both negotiated and imposed regimes at accomplishing these tasks because they do not "give rise to oppressive procedural requirements or armies of officials charged with implementing and enforcing the

terms of formalized regimes" (Young 1989, p. 93). More formal, or negotiated, regimes, in contrast, result in high transaction costs, while imposed regimes cannot guarantee distributional equity (Young 1989, p. 93). Independent of regime type, major events, such as environmental disasters, can increase the probability of successful regime formation, as actors have more impetus to come together to solve a shared problem (Young 1994, pp. 110–112). Generally, however, the literature suggests that a spontaneous regime may be the best option for solving a global environmental ill.

Actually assessing the effectiveness of environmental regimes, whether they are spontaneously created or not, can be difficult, but the literature contends that it is most expedient to consider regime effectiveness in terms of outputs, outcomes, and impacts. Outputs are the regulations created to solve the environmental problem at hand. In contrast, outcomes "encompass changes in the behavior of those subject to a regime's provisions that can be attributed in a convincing manner to the operation of the regime," while impacts refer to "the extent to which a regime plays a role in solving the [stated or unstated] problem that led to its creation" (Young 2013, p. 14). Additionally, international environmental regimes will find more success if they avoid "explicit attempts to define noncompliance" in the early stages of regime formation (Brunnee and Toope 1997, p. 57). This does not mean that the regime will never define noncompliance, just that the process should occur organically over time through the process of regime building. Above all, one must remember that environmental regimes are "apt to be hybrids that do not conform precisely to the essential features of any analytic type" (Young 1977, pp. 217–218). Flexibility and the constant evolution of social, political, and economic realities characterize these collective attempts to mitigate transboundary environmental issues.

River evolution: common interest to aversion

One cannot appreciate fully the collaboration over transboundary water and environmental policy in the Rhine basin without first tracing the river's historical development and its role in creating dilemmas of common interest and aversion for the Rhine's stakeholders. The Rhine River rises in Switzerland's Alps and continues on its meandering path over 1280 kilometers through Germany, France, and the Netherlands, eventually emptying its waters into the North Sea. Those riparian states, however, are not the river's only stakeholders, and other interested parties include the states of Italy, Austria, Luxembourg, Belgium, and Liechtenstein, which benefit from the hydropower and drinking water that the Rhine provides, even though these state actors collectively share a small percentage of the river's basin area (Frijters and Leentvaar 2003, p. 2).

Recorded Rhine River history stretches back over 12,000 years, with Ice Age hunters acting as the first boatmen on the Rhine traveling the river in search of food. Over the next several thousand years, the Rhine provided not only sustenance to local people with its accompanying abundance of flora and fauna, but also aided in the advancement of civilizations, a function most realized by the Celts and the Romans. These two societies utilized the Rhine's winding waterway as a trade route, primarily using the river for the transport of timber. Under Roman rule, the river was a public space, and "not subject to ownership, even of the state" (Chamberlain 1923, p. 142). Certainly, during the Roman era, there is little evidence of tolls being assessed for free passage through the river's waters, although "charges were made for the use of bridges" (Chamberlain 1923, p. 142).

The freedom of navigation common to the Roman era continued into the medieval period, as it was "frequently recognized in legal documents…and as an international right" (Chamberlain 1923, p. 145). In theory, then, the medieval Rhine was free for travelers and merchants to traverse, but the reality was more ambiguous—in fact, many princes of this period required monetary tolls before allowing passage down the river. Additionally, certain cities demanded that passing ships stop and unload their goods for sale within their borders, a practice known as *Stapelrecht*, or that passing ships stop to transfer cargo to local boats for further navigation, a practice known as *Umschlagsrecht* (Chamberlain 1923, p. 145). As the riverine stakeholders of the medieval age, the interests of cities and princes sometimes converged and these "organizations of common purpose are of special interest in a study of river organization" (Chamberlain 1923, p. 151). Indeed, early attempts to regulate the river generally revolved around economics, as involved parties attempted to maintain the river infrastructure so that all could derive benefit out of river trade—an attempt to solve a classic dilemma of common interest. For example, in the fourteenth century, territorial princes coordinated their efforts to regulate tolls that would help to pay for, among other items, the maintenance of the river's towpath (Chamberlain 1923, pp. 152–153).

Such cooperative efforts persisted over time with the rise and fall of rulers within the Rhine's geographic area. In 1804, during the rule of Napoleon, the Octroi of the Rhine, a formalized Franco-German arrangement, reduced the number of tolls on the river to twelve, while also standardizing the toll rates to eliminate "arbitrary and unpredictable fees" (Disco 2013, p. 275). The Octroi also served as a jointly managed bureaucracy meant to supervise toll collection on the entire river and to inspect towpaths, harbors and other facilities. In the process, this agency collected not only tolls, but also served as an information clearinghouse on the natural condition of the river. With the decisive defeat of France in 1813–1814, the Octroi was dissolved, but new governance arrangements emerged to take its place, and those arrangements continued to focus on the common interest of economic benefit as the primary function of shared river governance (Disco 2013, p. 275).

The modern Rhine, sometimes known as "Europe's romantic sewer", emerged in the Octroi's aftermath and accompanied the advent of the industrial revolution. Three related events marked the birth of this more modern period (Cioc 2002, p. 3). First, the Congress of Vienna (hereafter, the Congress) enacted a negotiated international regime to encompass the management of the Rhine in 1815, and this regime was designed to accelerate the free flow of trade, again highlighting the need for shared economic benefit among all of the riverine stakeholders. Indeed, the Congress created a uniform management system across all Rhine-adjacent states, by stating that "the system that shall be established both for the collection of the Duties and for the maintenance of the Police, shall be, as nearly as possible, the same along the whole course of the River; and shall also extend…to those of its Branches and Junctions, which, in their navigable course, separate or traverse different States" (Congress of Vienna 1815, Article CX).

The next year, 1816, introduced the first steamship on the Rhine, which heralded the start of the industrial age. Soon after, in 1817, engineer Johann Tulla began "the most ambitious rectification work every undertaken on a European river" (Cioc 2002, p. 3). This kind of physical manipulation of the riverbed was based upon engineering maxims of the time which advanced the idea that rivers were "potentially the 'enemies' of humans and therefore in need of being domesticated, tamed, or harnessed" (Cioc 2002, p. 39). The ideal waterway of this era was "straight, predictable, easily controlled, specifically

designed for navigation, not prone to flooding, easily contained within a single channel, and not so sluggish as to breed disease" (Cioc 2002, p. 39).

To that end, the Congress established the Central Commission for Rhine Navigation (the Rhine Commission) and tasked it with eliminating any of the river's chokepoints hindering commercial traffic—both anthropogenic chokepoints, like tolls and border checks, and natural chokepoints, such as reefs and waterfalls, stating that the "navigation of the Rhine shall be free to the vessels of all nations for the transport of merchandise and persons…no obstacle of any kind shall be offered to free navigation" (Rhine Commission 1868, Article I). Through this rerouting of the river's banks, the Rhine Commission succeeded at its central mission, as it managed to open up the river's navigability, subsequently stimulating the region's economic growth through commerce. This attempt to solve a dilemma of common interest—economic growth for all with increased navigability—"required the intercession of riparian states and encouraged specifically riverine modes of diplomacy and in some cases even transnational institutions for riverine governance to regulate matters like shipping and sewage disposal" (Disco 2008, pp. 23–24). To be sure, there were massive environmental consequences as a result of the Rhine's rerouting, as "all history is the history of unintended consequences, but that is especially true when [one is] trying to untangle humanity's relationship with the natural environment" (Blackbourn 2006, p. 85). Eventually, those environmental consequences transformed the Rhine's governance regimes from arrangements that attempted to regulate common economic interests to arrangements that coordinated reactions to the common aversions of pollution, flooding, and the loss of flora/fauna that began to plague the river's stakeholders.

The historical legacy of the Central Commission, then, was one of trade-related river transformation. Engineers eventually replaced meandering streams and a multitude of small river branches between Switzerland and Germany with a single river channel. The alteration of the riverbed, though, had many damaging effects on the region, including the introduction of catastrophic flooding. Areas that had served previously the function of absorbing water overflows were cut off from the river and replaced by concrete embankments to improve navigability. Over time, developers even used the dried marshlands created by this process for residential and industrial expansion. Eventually, such development reclaimed 90% of the river's wetlands, which exacerbated the Rhine's propensity to flood (Vajpeyi 1998, p. 131).

Development and modernization also helped to alter the Rhine's natural route, increasing industrial activity within the riparian states, which then required the construction of additional hydroelectric power plants. Over a period of several decades beginning in 1928, Rhine stakeholders built numerous hydroelectric power stations in canals parallel to the Rhine, which served to deplete water levels in the original bed of the river, and then in later years, the waters of the Rhine were used to cool nuclear power plants. Indeed, "electric power was and is a vital part of Western European economic success" (Lagendijk 2016, p. 24). These hydroelectric plants, and the subsequent damming of the river as a function of their construction, altered the ecology of the Rhine's fauna, especially in terms of migratory fish species such as salmon, which could not traverse the newly created dams in order to migrate and spawn (Wilken 2006, p. 59).

The rerouting of the river and its negative environmental consequences were not the only problems faced by Rhine stakeholders, and pollution emerged as a major factor in riparian health during the modern era. This is not to say that pollution had not previously existed on the Rhine—it certainly had, as "water pollution was recorded in towns and municipalities along the banks of the Rhine as early as the 1300s" (Myint 2012, p. 76). Due

to the more modern pressures relating to industrial development, however, the second half of the nineteenth century saw the Rhine become a dumping ground for manufacturing offal and raw sewage from growing local populations. The German government took note of the river's growing stench in 1901, when the Reichstag addressed the issue of the Rhine's transformation into a "sewer" and ordered its bureaucracy to canvas the Rhine for all sources of pollution. The results of the canvas found the following: a red sewage plume between Ludwigshafen "as far as Worms," "dirty waters carrying a medley of floating rests of dirt" near Frankenthul, and a pollutive Mannheim paper pulp industry adding "yellow water" to the body of the Rhine (ICPR 2008, p. 7).

Such pollution levels continued to increase unabated over time, and by the mid-twentieth century, conditions in the Rhine had deteriorated to such a low point that riparian states could no longer ignore the Rhine's heightened pollution level, its flooding issues, and the disappearance of its plant and animal life. The degradation of the Rhine, then, embodied a tragedy of the commons situation, as its stakeholders finally recognized that each individual input into the river, such as run-off from industrial development or sewage waste, while perhaps making sense from an individual point of view, actually degraded the overall quality of the river for its multi-national users (Hardin 1968, p. 1244). Thus, while the actions of the Rhine Commission had achieved their initial goal and opened up the river to trade and commerce, that same decision had also engendered unintended and negative ecological consequences related to the Rhine's increased commercial development. These ecological consequences then spurred a different type of coordination between Rhine stakeholders than had existed before, as stakeholder problems evolved from dilemmas of common economic interest to averting transboundary pollution, flooding, and the loss of riverine flora and fauna.

Regime evolution: from spontaneity to formalization

As the desire to avoid pollution, rather than inspire economic gains, became the common impetus of the Rhine's stakeholders, the type of regime created to deal with this dilemmas of common aversion began in much the same way as had previous regimes of common interest—the riparian actors first created a more spontaneous organization to manage the problem, or one without more formalized accounting of roles and results, but over time, legal treaties and governance documents emerged to then constitute negotiated regimes.

When confronted with the Rhine's pollution-related issues, for example, the river's stakeholders decided to confront the problem by creating a new organization entitled the International Commission for the Protection of the Rhine (ICPR) in 1950, to work separately from the Rhine Commission (whose main concern was trade). This first iteration of the ICPR stood as a spontaneous regime, as it lacked a more formal treaty/legal foundation, a problem which was later overcome with a 1963 treaty, informally known as the Bern Convention, that institutionalized its establishment (ICPR 1963).

At its inception, the Rhine's stakeholders requested that the ICPR work on restoring the river's health (thus solving a dilemma of common aversion), and to achieve that end, the new organization identified three major, albeit broad, objectives to structure its tasks: (1) researching the extent of pollution in the river and identifying its sources, (2) mitigating those sources of pollution, and (3) preparing corresponding international agreements to support those goals (ICPR 1963, Article 2). The ICPR relied on the voluntary participation of stakeholders to create an environmentally sustainable waterway, and as such, oversaw over a

decade later the creation of two formalized treaties aimed at mitigating Rhine pollution—the 1976 Convention for the Protection of the River Rhine against Chemical Pollution (Convention on Chemical Pollution) and the 1976 Rhine Chlorides Convention. For its part, the Convention on Chemical Pollution called for the elimination of certain "Annex I" (most toxic) pollutants in the surface water of the Rhine basin, while reducing the presence of "Annex II" (less toxic) classified pollutants in Rhine waters (ICPR 1976a, Article I). The Convention also recognized formally for the first time that the waters of the Rhine existed for multiple purposes in addition to commerce, such as the conservation of flora and fauna, fishing, and the "aesthetics" desired for recreational purposes (ICPR 1976a, Article I). Moreover, the mandates of the Convention lacked imposition to the extent that they contained little to no enforcement capacity or punitive measurements for offenders; instead, it was incumbent on members to self-monitor and report chemical pollution levels within the segments of Rhine water within their territories (ICPR 1976a, Article 10).

The Rhine Chloride Convention, in contrast, required the French government specifically to reduce its emission of chloride ions into the Rhine waterway (aimed largely at the environmental impact from France's salt mines), while it also asked all contracting parties to take the "necessary measures" to reduce chloride deposits in the Rhine River (ICPR 1976b, Articles 2 and 3). Additionally, the agreement laid out the specific division of payments between all of the stakeholders to achieve the treaty's objectives, but the treaty failed to mention enforcement of the treaty provisions; thus, both of the 1976 treaties stood as negotiated, or more formalized, versions of ICPR objectives, but still lacked elements of imposition, as it remained unclear what would happen to actors who defected from the agreements they had signed.

Many stakeholders disliked the ambiguity of these treaties, as they lacked enforcement power, and as a result, citizens and states began to call for additional action to clean the Rhine and solve what was perceived by much of the public as a very serious dilemma of common aversion. To that end, the International Water Tribunal (IWT) initiative, a meeting held in 1983, "called major water polluters into account for their failure to abide by standards of environmental morality," while also exposing the ways in which governments enabled big polluters to avoid accountability (Disco 2013, p. 302). The IWT's conclusion created a policy environment, which called for both a "transformation of the Rhine pollution regime" and the inclusion of non-state actors as part of the collective bargaining process over the river (Myint 2012, p. 111). The focus of this new abatement effort resulted not only in pressure to improve chemical pollution, but also centered on obliterating the image of the Rhine as Western Europe's sewer.

After the 1986 Sandoz chemical spill, the ICPR, as the relevant and already extant agency in this field, found itself spurred into even further action by public pressure, and shortly after the accident, negotiated amongst its stakeholders a plan to clean up "Father Rhine." That draft plan was non-binding, but was accompanied by formalized set of rules and regulations. Ultimately, it came to fruition in 1987 as the Rhine Action Program (RAP). The ICPR intended the RAP to achieve the following specific targets by the year 2000: the return of native fauna species to the Rhine (most importantly, salmon); the reduction of the pollutant contents of river sediments; the acceleration of a reduction in permanent pollution from point and non-point sources; the reduction of accident risk (no doubt a direct consequence of the Sandoz chemical spill); and the improvement of hydrological and biological conditions within the river (ICPR 1987).

At its core, then, and true to the earlier stated objectives of the ICPR, the RAP focused on pollution mitigation, but the specter of an additional problem appeared during the winters of 1993 and 1994 and forced the further evolution of the RAP. Severe flooding on

the banks of the Rhine during those years caused the deaths of four people and resulted in large-scale evacuations of Rhine-adjacent populations. In the wake of these calamities, ICPR stakeholders realized that the anthropogenic rerouting of the river (due to the actions of the Rhine Commission) was at least partially responsible for the severity of the flooding and vowed to address that situation by merging pollution control solutions with flood control measures via the RAP.

In 1999, these efforts resulted in a binding treaty to address the Rhine's ills, specifically the Convention on the Protection of the Rhine. The contracting parties of the Convention were the European Community, France, Germany, Luxemburg, Netherlands, and Switzerland, and the Convention's stated goals included preventing pollution within the river, improving safety measures for plants on the river and reducing the potential for industrial accidents, protecting biodiversity, improving the natural function and flow of the Rhine's water, providing clean drinking water from the Rhine's banks, improving flood prevention measurements, and, by improving the quality of the Rhine, also restoring the health of the North Sea (ICPR 1999, Article 3). The entry into force of the Convention repealed the April 1963 Agreement concerning the International Commission for the Protection of the Rhine against Pollution, as well as the 1976 Rhine Convention on Chemical Pollution. The ICPR, though, still played a major role as a coordinating body in the new treaty, and its tasks included preparing studies on the Rhine's ecosystem, making proposals for action, evaluating effectiveness of implementation measures, coordinating warnings and alerts, and keeping the public informed about its legislative progress (ICPR 1999). Additionally, this new treaty still relied on self-reporting of implementation measurements and emphasized negotiation and arbitration as the means to mitigate any disputes, meaning that, although it certainly served as a more formalized and binding set of rules by which states should abide, it still lacked specified enforcement capacity and imposition of the rules from a higher authority (ICPR 1999, Articles 11 and 16).

The next historical evolution: from negotiation to imposition

In 2000, the European Union, an institution to which the vast majority of the river's stakeholders belong (with the exception of Switzerland), spearheaded the most recent iteration of Rhine regimes by adding an element of imposition and compliance into the Rhine's management framework. The EU achieved this evolution in regime type by adopting the Water Framework Directive (WFD); a comprehensive policy structure intended to provide legislative cohesion regarding the region's water management (European Parliament and Council 2000). As a legislative framework, the WFD fused the many disparate mechanisms of European water management into a one unified policy for application across all transboundary EU water resources, including the Rhine. Among its many mandates, the WFD provides for "a sustainable and integrated management of river basins including binding objectives, clear deadlines, [and a] comprehensive program of measures based on scientific, technical and economic analysis, including public information and consultation" (European Union 2003, p. 2).

Indeed, one core element of the WFD was a call for transboundary water cooperation through the establishment of international river basin districts (IRBDs), a designation to which the Rhine River belongs. River basin districts are flexible, as over time, they tend to "reconfigure themselves in order to accommodate local scales and processes, and the diversity of stakeholders and interests" (Molle 2009, p. 492). The WFD legislation requires

member states to ensure that a river basin located in the territory of more than one state is designated as an IRBD, and IRBDs must have an appropriate implementation authority assigned as well. For practicality's sake, member states are allowed to utilize already existent international administrative organizations for the WFD's implementation (European Union 2002).

To guide the management of IRBDs, the WFD requires EU states to produce river basin management plans (RBMPs) for all river basins to which waters within a state belong, allowing for tailored local control nested within the larger EU framework. The RBMP is central to river basin planning, and states were to produce their first such plan in 2009, with a subsequent update of that plan every 15 years. The RBMPs must include, on a variable deadline schedule, a summary of the river basin's health in terms of pollution and ecological sustainability, an account of pollution abatement measures, an economic analysis of water use and pricing, and a summary of the stakeholder consultation process. Future updates of RBMPs should assess any progress made in achieving pollution abatement objectives, account for any objectives that are not yet achieved and explain that failure of achievement, while also evaluating the future of the IRBD. Thus, the RBMPs act as a type of accountability tally, as they track the status of each international river basin district over time (European Parliament and Council, Article 13 and Article 4.3).

Moreover, in terms of its role as an imposed regime, the WFD also provides clear deadlines for all measures listed above, something that previous Rhine legislation lacked. For instance, it required states to establish IRBDs and competent coordination authorities by 2003. By 2004, states had to provide an analysis of the characteristics and pollution levels within each IRBD, and by 2006, states had to establish a monitoring mechanism for IRBD progress. Furthermore, states had to present a draft RBMP to the public and all interested stakeholders by the end of 2008, and by December 2009, states were required to submit a final draft of each RBMP to which its waters belong. Ultimately, by 2015, each EU water source had to meet the environmental objectives laid out in its respective RBMP, at which point the EU expected the evaluation process to begin anew for a second cycle (European Union 2002, p. 65).

In terms of the legislation's execution, the WFD allowed for states to determine which administrative bodies would oversee its implementation, and the role of extant organizations was critical to this process. Indeed, Rhine stakeholders agreed in 1999, with their accession to the Convention on the Protection of the Rhine, that the ICPR stood as the organization best poised to implement the WFD within the Rhine region. Then, in 2001, the ICPR was able to transition successfully its efforts into the Rhine 2020 plan, an adaptation of the Rhine Action Program that conformed more closely to WFD sustainability requirements. Essentially, then, the Rhine 2020 program exists as the ICPR's operationalization of the WFD, as it attempts to support the Rhine's sustainable development. The targets of Rhine 2020 include the continued improvement of ecological conditions within the Rhine watershed, specifically incorporating the reintroduction of salmon into the Rhine, the improvement of flood prevention, the improvement of water quality and groundwater protection, and the continued surveillance of the Rhine River for the maintenance of its integrity (Rhine Ministers 2001, pp. 6–7). Finally, in pursuit of the new Rhine 2020 goals, the ICPR created a Coordinating Committee consisting of representatives from Germany, France, the Netherlands, Austria, Switzerland, Belgium, Luxembourg, Liechtenstein, and Italy to oversee the plan's implementation.

Rhine 2020: solving a dilemma of common aversion

The strength of the Rhine region's pre-existing management regime, the ICPR, allowed that organization to successfully implement a transboundary regime in the Rhine River basin, while, at the same time, complying with the legislative mandate of the WFD. The working definition of success in this case adheres to the vision presented by the literature on environmental regimes, which assesses success based upon the three metrics of outputs, outcomes, and impacts of a particular policy structure. In terms of *outputs*, or the creation of regulations to solve the environmental problem at hand, the Rhine 2020 program, in conjunction with the WFD, contains detailed and clearly defined policy objectives within a robust regulatory framework (such as mandating creation of IRBDs and RBMPs), strict implementation schedules (as outlined above), and measurable ecological and pollution-related goals.

As for *outcomes*, defined as changes in stakeholder behavior that are attributed to the governing regime, those are present as well and are evident in the ways that Rhine-adjacent countries have aligned their actions within their own borders so that they are compliant with the mandates of the Rhine 2020 plan. For instance, the contracting parties have built new sewage systems or adapted older ones in order to combat zinc and copper in the river due to "the rainwash of contaminated dust" (ICPR 2013, p. 20). Additionally, the Rhine stakeholders have taken a myriad of actions to improve fish migration by building new dams and reconstructing existing dams to account for fish passages upstream. In fact, the ICPR credits explicitly the influence of the WFD regime for spurring so much improvement in fish migration across the Rhine, stating that it (the ICPR) had previously not set a target for the number of dam structures to be altered, but that their current success in this area is "clear evidence of the acceleration measures brought about by the implementation of the program of measures under the Water Framework Directive" (ICPR 2013, p. 10).

Finally, when assessing the *impacts* of the Rhine 2020 policy framework, or the extent to which the initial problem at the heart of the policy has been solved, the quantitative numbers speak to the program's impact. In terms of ecological improvements, significant progress has been made in resurrecting natural floodplains, reducing alien and invasive species in the Rhine waters, and restoring the river's continuity. In terms of floodplains alone, by 2012, 122 km^2 of surface land had been reactivated, well within sight of the 2020 ultimate goal of 160 km^2 (ICPR 2013, p. 7). Additionally, water quality within the Rhine has improved significantly, and industrial, agricultural, and chemical pollutants have decreased in number. The fauna of the Rhine has also improved over the last two decades, and the results of the migratory fish reintroduction into the Rhine river system (a component of the "Rhine 2020" program) speak to this advancement. Since 1990, more than 5000 adult salmon have returned from the North Sea and migrated upstream, but importantly, much of that progress has occurred within the last ten years due to the construction of fish passages at several of the Rhine's hydroelectric dam sites. Thanks to joint German and French efforts, the Iffezheim fish passage, a migratory route bypassing a hydroelectric dam, was opened in 2000, and between 2001 and 2004, three new fish passages were created in other areas of the Rhine delta. Additionally, in 2006, Germany and France again collaborated and opened the Gambsheim fish passage on the Upper Rhine (ICPR 2008, p. 22). Of course, it is important to note that all of these impacts (which one should note are only a small sampling of the regime's quantitative impacts), do not imply that all pollution has disappeared from 'Father Rhine,' and the ICPR readily acknowledges that there is still

further improvement to be had for the full attainment of the 2020 benchmarks (ICPR 2014).

Collaboration and coordination: lessons and policy prescriptions for other states

Today, the Rhine River serves as a heartbeat for Western Europe, supporting the population by providing drinking water, as well as serving as a juggernaut of industrial activity. And that river has undergone several significant evolutions over time—evolutions in the path of the river itself, in the type of dilemmas faced by its stakeholders, and in the structure of regimes created to oversee its governance. It is from the study of those historical evolutions that scholars can formulate policy prescriptions for modern transboundary river governance.

The Rhine's early management regimes were initially spontaneous creations, which eventually became formal arrangements, as best exemplified by the Congress of Vienna. These regimes tended to frame the river's meandering geography as a hindrance in the free trade of goods between local stakeholders. Facing this dilemma of common economic interest, the river's earliest managers attempted to solve the problem by regulating the Rhine's commerce through increasing its ease of navigability, paying little mind to the environmental effects of the river's re-engineering. Eventually, stakeholders recognized that the economic development of the river had led to a dilemma of common aversion in the form of deleterious pollution, and they followed a similar pattern to previous regimes—first organizing themselves into spontaneous, turned formalized, governance regimes, like the ICPR and the Conventions on Chemical Protection and Chloride, that focused on improving the river's ecological integrity, but lacked explicit compliance mechanisms. The Sandoz environmental chemical spill in the late twentieth century, however, along with increased flooding and the loss of fish and plant life within the Rhine, introduced a sense of urgency and catalyzed the Rhine's stakeholders into finding approaches that were more binding in their approach, helping to convince riparian actors that the Rhine was "not just a geological entity—a construct of plate tectonics, volcanic activity, climatic variation, soil erosion, and other natural processes", but was also "a human artifact, a techno-river, [and] a thoroughly anthropomorphized stream in Europe" (Wilken 2006, p. 51). The creation of the European Union's (EU's) Water Framework Directive (WFD) and the subsequent Rhine 2020 plan, further supported and operationalized this new focus on the Rhine's environmental health. The additional element of power and legitimacy provided by the EU's dense institutional network today holds the Rhine's bordering states accountable for breaking the rules of the regime, as the EU has the ability to encourage compliance by punishing states who defect from their environmental agreements (European Commission 2014). The WFD enabled the ICPR to tailor a coherent, holistic approach to water resource management specific to the Rhine region (Rhine 2020), while still adhering to the larger vision governing all EU transboundary water sources.

This is not to say that the lessons present within a study of the Rhine's historical governance regimes are transferable to all other transboundary waterways, and certainly, the opposite is the case. There are many factors surrounding the Rhine that make its experience unique. In fact, it is the long history of formal water governance over the Rhine that makes it such an unusual case, as the river's history of negotiated water management regimes spans over 1000 years, and resulting in the European Union's Water Framework

Directive. Although it is quite conceivable that riparian actors across the global have been managing their transboundary waterways through a series of long-standing spontaneous arrangements, the history of legal agreements and international treaties that govern the relevant riparian states is unique to the European context, and in this way, the Rhine experience is distinctive.

And, of course, the Rhine's dilemmas of common interest and aversion never centered on resource scarcity. Stakeholders may have believed in managing the Rhine's economic potential or believed in cleaning up the polluted resource for the sake of its users, but historically, the water of the Rhine has not been a scarce resource, and there has been adequate water to allocate between stakeholders. Thus, for states around the globe with rivers that suffer from physical water scarcity, the experience of the Rhine is unlikely to be directly applicable. Instead, a situation of extreme physical water scarcity would likely engender more conflict over water resources than a situation in which pollution can be mitigated with technological advances. Obviously, where water does not exist, there is little one can do to create it out of thin air—that is a very different and more acute type of problem for states to face and one that more likely hinges on power politics between stakeholders and the power differential between upstream and downstream stakeholders.

Thus, while the fungibility of the Rhine's governance lesson may face certain limitations in their broad application, there are still two policy prescriptions that emerge from this analysis for consideration, as a variety of states consider the creation or their membership in transboundary river regimes. The findings within this case study both support and oppose the environmental regime literature. On the one hand, the evolution of the Rhine's historical governance regimes suggests ultimately that transboundary water cooperation, though it is always a challenge, is aided by a *shared history of water governance*. The "shadow of the future" becomes incredibly important in this respect. When states work together over long periods of time, they have the luxury of identified areas of common interest and common aversion, and that long-standing relationship enables them to create formalized, and perhaps imposed, agreements to address their shared water concerns. Consequently, the experience of the Rhine stands in contrast to literature on environmental regimes that emphasizes spontaneous regimes as the most important incubators of successful transboundary water management. Instead, the case of the Rhine suggests that spontaneous regimes are certainly a necessary condition, but that a measurement of long-range outputs, outcomes, and impacts to improve water quality in the Rhine's case may require elements of formalization at the least, and most likely also an element of binding imposition and clear-cut accountability mechanisms to engender long-term cooperation and results over transboundary water issues.

The second governance lesson exemplified by the Rhine is that *collaboration among stakeholders does not require a crisis to work*, although said collaboration may transform into coordination due to a newly discovered dilemma of common aversion. The environmental regime literature posits that major events, such as the Sandoz environmental disaster, can increase the probability of successful regime formation, as actors have more impetus to come together to solve a shared problem (Young 1994, pp. 110–112), but the Rhine's legacy opposes this notion, as the Rhine exemplified collaboration over a dilemma of common interest long before environmental consequences became a primary concern of riparian states.

So what broad-based policy prescriptions emerge from the Rhine's story? The primary take-away here is that riparian actors the world over should begin to identify dilemmas of common interest between them and take the first steps to create spontaneous regimes as a way to establish a shared history of governance and a shadow of the future among

themselves. This is the lesson and this is the policy prescription—they are one and the same. Collaboration does not require a crisis—it simply requires that actors identify their common issues, be they economic or otherwise, and work slowly to build organizations addressing those interests in a non-binding and informal way. Then, if a crisis should occur at some point in the future, those stakeholders have an already established institutional mechanism through which to begin to address it and advance more intense coordination between actors. Hence, the history of governing collaboration over the Rhine River basin demonstrates that identifying a common purpose, ANY common purpose, is the first step for states to build stronger networks of institutional water governance over one of the globe's most precious and shared natural resources.

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