From Cournot to the Commons:
An Analysis of Regulatory Property Rights

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Abstract

In 1838 Augustin Cournot defined the concept of a "complementary oligopoly," where two (or more) independently held inputs are required in order to produce a single output. He also showed that efficiency was achieved when the complementary inputs were supplied by a single firm, rather than competing firms, as any hold-up incentive would be internalized by a single firm. It was the first instance in the literature where consolidation of market power was actually a welfare improving outcome. Recently, the complementary oligopoly paradigm has been adopted in the legal literature and rebranded the "anticommons" (Heller, 1998). In this paper, the paradigm is extended still further by applying it to the regulatory sphere. The contextual example is river-basin water regulation in the U.S., where a vast array of regulatory agencies all exist as independent rights holders into river-related regulatory procedures. As each agency monopolistically controls a particular aspect of river-basin water management, it has the incentive to hold out and require individual demands that, altogether result in high costs and inefficient outcomes. Reform of the regulatory system, towards greater consolidation as Cournot first suggested, would lead to welfare-improving outcomes.

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Introduction

In 1838 Augustin Cournot (1963) described what happens in a market when two complementary inputs (say copper and zinc) are both necessary to produce a single composite output (brass). In such a situation, if the complementary inputs are held by independent firms, then each of these firms has an incentive to hold-up ultimate production of the good, brass, by demanding monopolistic rents for their material. These high input price demands will subsequently lead to high prices for the output which ultimately harms consumers, leads to deadweight loss, and is socially inefficient. It was the first case in the literature where *consolidation* of market power was suggested as a welfare improving outcome. Cournot showed that aggregate welfare in this instance of a "complementary oligopoly" was actually improved if the complementary inputs were supplied by a single monopolist, rather than by competing and independent firms, as the monopolist would internalize any negative cross-price effects from the inputs and arrive at a lower combined price.[1]

Recently, the complementary oligopoly paradigm has been seized upon in the legal literature to describe situations where multiple complementary rights owners to a resource exist. Coined the "anticommons" (as opposed to the "commons," where no rights holders to a given resource exist) in a pathbreaking article by Heller (1998), in such a situation optimal utilization of a resource is hindered by the hold-out incentives of every one of the independent rights holders. Ultimately, this leads to inefficient outcomes and welfare is only improved when, as originally suggested by Cournot, the independent rights holders are somehow consolidated.

In this paper we extend the paradigm still further by applying it to the regulatory sphere. There exist regulatory procedures that embody a diverse array of regulatory agencies such that,

[1] The mathematics of this result is easily derived by showing that the price derivatives from the individually monopolistic profit functions are together higher than a single derivative would be from a composite profit function (Cournot, 1963; Schulz et al., 2002).

without coordination, hold-up behavior and bureaucratic sclerosis results. This story is applicable, for example, to riverine regulation in the U.S. today. Numerous regulatory agencies each control aspects of river-basin water management in the U.S. so that to produce any single output (such as increased instream reserve requirements, small scale hydroelectric power permits, or agricultural-municipal water transfers) numerous, sometimes repetitive and inefficient regulatory requirements must be satisfied. The result is suboptimal utilization of river-basin resources in the U.S. today.

This paper contributes to the literature in two ways. First, it develops the concept of a "regulatory anticommons," which extends the complementary oligopoly paradigm of Cournot to the regulatory sphere.[2] Second, it offers a contextual example and policy implications for river-basin water management in the U.S. today. Many demands are currently being made on the limited river-basin water resources of the United States, from irrigation to recreation to municipal uses. This large set of demands poses a problem because supply is essentially stagnant. Looking forward, this situation of water resource scarcity is only projected to worsen as climate change effects and continued population growth are added to the mix (Carrillo and Frei, 2009). Given this acute state of affairs, reform of the fragmented, uncoordinated regulatory system as it exists today offers welfare improvements.

Literature Review

The term "complementary oligopoly,"[3] as first described by Cournot (1963), has since its original publication in the literature been applied to a number of contexts, including telephone service and (particularly in the days of Ma Bell) the telephone equipment used to access it, or

[2] Note that this paper attempts to extend the analysis to regulatory contexts only, and not legislative, judicial, executive, or other political power contexts.
[3] Sometimes also referred to as a "complementary monopoly" in the literature.

computer hardware and the software used to run it. More recently, McHardy (2006) and Gisser and Allen (2001) discuss its application to the case of Microsoft and the wisdom of breaking Microsoft up into complementarily distinct firms. Chari and Jones (2000) have applied complementary oligopoly theory to an analysis of global public goods, and Feinberg and Kamien (2001) and Else and James (1994) discuss the implications of a complementary oligopolistic model for travel along privatized road, canal, and rail segments. The conclusion that complementary oligopolies are inefficient and that improving on the inefficient outcome involves some degree of coordination or consolidation of the independent firms appears to be well established.[4]

What is novel in the literature is the continued application of this theory into new realms of analysis. In 1998, for example, Heller brought the complementary oligopoly paradigm into the legal literature with an analysis of storefront property in Moscow after the breakup of the Soviet Union. At that time kiosks selling all manner of goods sprouted on the streets outside of traditional storefronts, while the brick-and-mortar stores themselves remained empty and underutilized. The reason for this unexpected outcome, Heller noted, was a proliferation of property rights after the breakup of the Soviet Union to an array of distinct property rights owners who could not agree on how to use the storefront property. While the property rights owners dithered, kiosks emerged to satisfy the burgeoning demand for produce.

This situation, of numerous rights holders to a single good, Heller recognized as the mirror opposite of the well-known situation of the commons, where no rights holders to given resource existed.[5] As the commons can lead to the Tragedy of the Commons and overutilization

[4] Although McHardy (2006), and to some extent Economides and Salop (1992), make the important point that if entry can be induced in the input firm markets, this is superior to consolidation. The assumption here, which is particularly applicable to the regulatory sphere, is that it cannot.

[5] Heller references the first mention of the term "anticommons" to Michelman (1982).

of a resource (Hardin, 1968), so the anticommons can lead to the Tragedy of the Anticommons and underutilization of a resource (Parisi et. al, 2005; Buchanan and Yoon, 2000). Since publication of Heller's insightful essay, other legal applications of the anticommons tragedy have followed, for example in the pharmaceutical and scientific research industries where innovation often requires the coordination of multiple patent-holders (Murray and Stern, 2007; Dari-Mattiacci and Parisi, 2006) and with digital innovation by artists that requires the combining, cutting and pasting from numerous creative works (Parisi and Depoorter, 2003).

Reading accounts of modern regulatory behavior, a similar type of sclerosis appears to emerge in many instances. For example, Brunetti (1991) points out that the San Francisco Bay Area, a 7,000 square mile region covering approximately seven million people, has within it over 100 distinct municipalities.[6] Each of these municipalities has its own elected officials, its own zoning laws, taxes, refuse collection regulations, and more. This fragmentation of governing authority over a dispersed number of regulatory bodies has led to management difficulties in the past. An example is the Bay Area's attempt to create a Bay Area Rapid Transit District. In 1949 the California legislature passed an act that provided the framework for a transit system that would cover the entire San Francisco Bay Area and connect the many disparate municipalities. When the initial act was passed it was enthusiastically supported by local officials who helped in forming the commission (the Bay Area Rapid Transit Commission, or BART) that was instructed to implement the comprehensive transit district system.

Despite initial support, however, once it came time to iron out the details, the conglomerated governing authority quickly began to bicker over local priorities and specific track routes. As there was no overall governing authority, and each individual county effectively

[6] Brunetti officially lists 98 distinct municipalities covering a population of approximately six million people, but in the time since that article was published, things have grown.

had veto power over the program, the comprehensive BART system as initially envisioned, despite repeated attempts, has never been created. The BART system that exists today is a mere skeleton of the system originally envisioned, serving only four counties and a much reduced (and many would say suboptimal) geographic area.[7, 8]

Another example of ineffective management due to fragmented regulatory control concerns aquaculture. As Buzbee (2003) points out, aquaculture is a geographically well-defined production activity that generates local benefits in the form of jobs and tax revenues. Any particular aquaculture business, however, is part of a broader industry that has transboundary concerns such as overuse of antibiotics, disposal of concentrated organic matter produced by the fish, and bioengineered fish escaping into the natural, local ecosystems. These larger issues are not currently regulated in any kind of a coordinated, centralized fashion, but are instead addressed in an ad hoc way by state and local fisheries agencies and natural resource departments. These local agencies do not agree on regulatory priorities, therefore, the comprehensive, long term ecosystem risks of aquaculture are often ineffectively managed. There is still no agreement on pollution and other transboundary aquaculture issues and the threat of infestation from bioengineered fish to local fishery populations remains.[9]

Finally, Dixit (2009), Easterly (2001), Shleifer and Vishny (1998) and others have written on the inefficiency of disorganized crime networks. When a criminal network is run by a single family or agency with monopolistic top-down control it has an incentive to limit the

[7] Similar ineffective policy results due to fragmented regulatory control has also, according to Brunetti (1991), occurred over land use, water supply, and solid waste issues, as well as being one of the determinants of urban sprawl.

[8] Another example of municipal fragmentation comes from the city of St. Louis, Missouri. St. Louis County is approximately 500 square miles and covers a population of around one million, but has within it 91 distinct municipalities that, notoriously, each maintain their own police force. Stories abound about the inefficiency and confusion that result when patrol cars on the street change jurisdiction every two blocks.

[9] Effective oversight can come from broad regulatory authority, but it doesn't necessarily have to. Ostrom (1990, 2000) has documented the ability of non-governmental agencies, such as control boards or trade associations, to effectively manage group concerns, in the right circumstances.

amount of bribes and extortion that occur at lower levels of the supply chain because too much corruption effectively stifles business activity and reduces overall take. Diffuse criminal activity, however, like in the Russian economy after the breakdown of the Soviet Union or in rural parts of Africa and India today (Shleifer and Vishny, 1998), suffers from corruption and bribes at all levels of business activity and these repetitive layers of extortion eventually stifle the entire economy.[10] When any criminal network, from the drug trade to the mafia, engages in illegal activity from a diffuse network of control, the result is overextension and a stifling of aggregate revenues. It is the criminal networks that are run by a single agency or organizing family that are ultimately the most effective, and protective, of their underlying businesses.

More broadly, all of these examples illustrate a regulatory coordination problem. There exists a socially optimal level of production of a good (transit development, aquaculture regulation, bribery), but without coordination of the overlapping players involved, optimality is not guaranteed. This is a prisoner's dilemma, where each player acting independently in his own best interest fails to internalize the externalities of his actions on the other players, and so a suboptimal (if dominant strategy) Nash equilibrium results. In the classic prisoner's dilemma game all players in an activity, be it criminals in a drug supply chain or regulators in the aquaculture industry, are interested in maximizing their own personal gain, irrespective of the broader gains that could be achieved by working together. Self interest and a limited perspective reduces the benefits to society as a whole. Suboptimal outcomes are inevitable in such a situation, without some sort of coordinating authority or broader institutional structure that brings the parties together. In the municipal, aquaculture, and crime examples noted above, the regulatory framework fails because numerous regulatory "rights-holders" all claim distributive

[10] Ben and Jerry's is a classic example of one of the many businesses that tried to expand into Russian after the fall of the Soviet Union, but suffered fatally from bribery and extortion demands (McKay, 1997; O'Brien, 1992), among other things.

rights into the process which leads, when uncoordinated, to suboptimal, overextended systems and, ultimately, to socially inefficient outcomes.

In this paper we hypothesize that this is what is happening today with river-basin management in the U.S. First we provide a history of river-basin regulatory management in the U.S. and document its growing fragmentation. Then we provide a theoretical model which applies the anticommons tragedy to the regulatory sphere. After that we provide some evidence for the anticommons phenomenon in river-basin regulation in the U.S., and in the final section of the paper we offer conclusions and policy prescriptions for reducing the inefficiencies currently inherent in river-basin water regulation in the U.S.

River-Basin Water Regulation in the U.S. – A History

The history of river-basin water regulation in the United States arcs a pendulum swing from dispersed, decentralized regulatory control to coordinated, centralized management, and then back again. In the country's early days local, and perhaps state governments provided the oversight (if any) of water use projects while the federal government largely kept out of the way. There was no centralized organizing bureaucratic agency or comprehensive legislative mandate that monitored water maintenance or productive usage. But by the turn of the twentieth century, with the fruition of the Industrial Revolution at its height, settlement of the West proceeding apace, and economic development a national priority, the interstate nature of river flows and the need for coordinated economic development of these resources catalyzed the federal government into taking a more coordinated, centralized role in management of the nation's rivers.

The first piece of federal legislation that passed in this vein was the Rivers and Harbors Act of 1899. The Rivers and Harbors Act prohibited construction projects on navigable

waterways of the United States without Congressional approval, and required permits for any kind of refuse discharge into the nation's rivers. Centralized control of river system management was further solidified in 1920 by passage of the Federal Water Power Act (FWPA), which coordinated hydropower development along the nation's rivers. In the early 1900s hydropower accounted for more than 40% of total U.S. electricity supply (and more than 75% of electricity supplied in the West and Pacific Northwest) and the outlook for further hydropower production was strong. The FWPA was noteworthy in that it created a single bureaucratic agency, the Federal Power Commission (later renamed the Federal Energy Regulatory Commission (FERC)), to monitor riverine development and issue hydroelectric power licenses from a centralized agency. For nearly half a century development along the nation's riverways was managed from this more centralized perspective.

In the late 1960s and early 1970s this coordinated focus began to dissolve. The country's burgeoning environmental movement found expression in new legislative mandates that, however indirectly, chipped away at the centralized control FERC and the federal government exercised. The Wild and Scenic Rivers Act (1968), the National Environmental Policy Act (1969), the Clean Water Act (1972), and the Endangered Species Act (1973) all passed, creating new bureaucratic agencies and new bureaucratic regulations. Similar pieces of legislation passed at state and local levels, including "little NEPAs," or state environmental policy acts, as well as state water quality acts and endangered species protection requirements. None of this legislation *directly* amended the Federal Water Power Act (or its successor, the Federal Power Act), but it did disperse water system management by requiring increased levels of oversight through different layers of bureaucratic control. By the mid 1970s the United States had effectively entered its third phase of river system management, with the pendulum having swung towards a

much more dispersed, decentralized form of control, albeit one with more regulatory layers and agencies than the first time around at the dawning of the nation's history. Today, few (if any) water use projects of any type (developmental, recreational, in-stream) can be developed without satisfying a myriad of bureaucratic regulations from various levels of oversight.

This new state of affairs is not necessarily a bad thing. The slate of environmental legislation that passed in the latter half of the twentieth century did so because the nation's preferences had clearly changed from one focused predominantly on economic growth, to one balanced on preserving the environment alongside economic development. The problem, however, is that the newer regulation was added in layers on top of earlier regulation, rather than in a comprehensive way from any sort of a coordinated perspective. Judicial rulings were subsequently needed to sort out the overall control issues[11] and help determine bureaucratic priorities[12] (Kosnik, 2006; Blumm and Nadol, 2001; Blumm, 1986), unfortunately, not always successfully. Judicial tug-of-wars over priorities, requirements, and power sharing continues. Today, river systems in the U.S. are regulated in a fragmented, dysfunctional manner that makes it difficult to address contemporary issues like renewable small scale energy development and climate change effects in a quick and comprehensive manner.[13]

At the turn of the twenty-first century, therefore, we have come full circle, from an effort to consolidate and centralize water resource management, to an apparent (though largely

[11] For example, a series of court cases in the 1980s and 1990s spoke to the issue of state and other agency rights in imposing conditions on hydroelectric licenses (*Escondido Mutual Water Company v. La Jolla Band of Mission Indians* (1984), *California v. FERC* (1990), *PUD No.1 of Jefferson County v. Washington Department of Ecology* (1994), *American Rivers v. FERC* (1997), *American Rivers v. FERC* (2000).

[12] The court cases listed above, as well as others (*Tulalip Tribes v. FERC* (1984), *Confederated Tribes & Bands of the Yakima Indian Nation v. FERC* (1984)) also helped to shift FERC's focus toward environmental and recreational protection.

[13] Examples of fragmented and uncoordinated river-basin regulation in the U.S. abound. In Hawaii, for example, the small scale Wailuku River hydroelectric river project had no opposition (environmental or otherwise), yet it still required separate regulatory permits and approval from the Department of Land and Natural Resources, the Army Corps of Engineers, the State Environmental Health Division, the state Commission on Water Resource Management, and the federal Coastal Zone Management Program. This uncontested permitting process cost millions of dollars and took nearly five years to complete (Barnes, 1993).

uncoordinated) effort to disperse watershed management among layers of bureaucratic agencies at the local, state, and national levels from a myriad of legislative contracts. A slow and fragmented regulatory process has its compensating benefits. It allows for greater citizen participation and in so doing broadly legitimizes any final regulatory outcome. However, there is a tradeoff. Sclerosis, slowness, and lack of an ability to approach new, complex problems like renewable energy development and climate change induced fresh water scarcity.

Model

Applying the complementary oligopolistic model to the regulatory sphere is relatively straightforward. Building on the examples given in Cournot (1963), Parisi and Depoorter (2003) and Schulz et al. (2002), we assume a number of regulatory agencies, n, each with an independent property right in a given river-basin related regulatory process. The final outcome of this regulatory process, q, is some sort of regulatory action such as a license to construct a small scale hydroelectric plant, or a permit for an in-basin water transfer. p_i is the price from each independent regulatory agency i, ($i = 1, \ldots, n$), and consists of such things as informational studies, bureaucratic reports, and other forms, analyses, and documents necessary for regulatory approval.[14] We assume in this model that there is no real overlap, in other words, that $p_i \neq p_{i+1}$ and that each regulatory agency sets its own requirements for approval independently and in an uncoordinated fashion from the other regulatory agencies.[15] Because regulatory approval from *all* agencies is required before q is granted, these approvals, whose price is p_i, act as strong complements in the production of the final good q. In other words,

[14] We are assuming the regulatory agencies set prices, not quantities, as necessary for their regulatory approval, although the distinction in this context does not make any difference (Parisi et al., 2004; Schulz et al., 2002).
[15] In reality, there may be some overlap between the regulatory requirements of different regulatory agencies, but in such an instance it would only reduce the inefficiency result generated from the model, not eliminate it.

$$p_q = \sum_{i=1}^{n} p_i \quad (1)$$

The key to the classic complementary oligopolistic result is to show how each p_i is determined. We assume that each regulatory agency faces a maximization function,

$$\max_{p_i} E_i = p_i D(p_q) \quad (2)$$

where E_i is defined as policy effectiveness, and $D(p_q)$ is the demand function. Improved policy effectiveness brings a host of benefits to the regulatory agency including public relations benefits, increased budgetary allotments, reduced congressional/legislative oversight, and enhanced power. Policy effectiveness itself is left vaguely defined[16] except to say that, as regulatory agencies are currently institutionalized, it is assumed to increase monotonically with an increase in regulatory activity and regulatory mandates, as embodied in p_i.

Differentiating the maximization functions for each regulatory agency yields the following characteristic first order condition:

$$\frac{\partial E_i}{\partial p_i} = p_i D'(p_q) + D(p_q) \quad (3)$$

Summing the first order conditions across all n regulatory agencies in order to achieve the equilibrium price for q gives us:

$$p_q D'(p_q) + nD(p_q) = 0 \quad (4)$$

Compare this to the results that are derived if instead of multiple, fragmented regulatory agencies all acting as rights holders into the process, there were but one single regulatory agency overseeing the entire procedure. In such an instance, the maximization function would be

$$\max_{p_q} E_q = p_q D(p_q) \quad (5)$$

and the first order condition for setting price would be

$$p_q D'(p_q) + D(p_q) = 0 \quad (6)$$

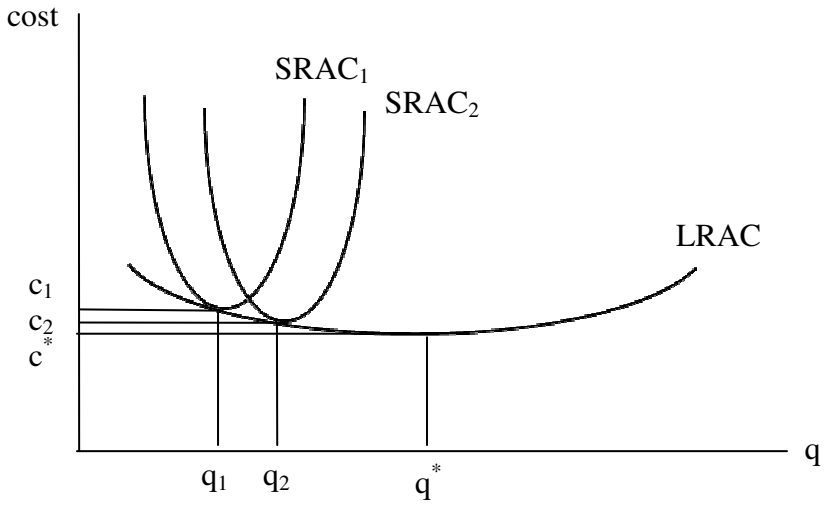
[16] As it is in regulatory capture theory and public choice theory models as well.

Note that the price under a single regulatory agency (6) is lower than the total price of the composite good under the complementary oligopoly (4), and that this difference (and the inefficiency and welfare losses that correspond to it) increases with n.

Interpretation of this model tells us that, in maximizing the individual mandates, E_i, each regulatory agency chooses his price, p_i, so that it will maximize individual profits, irrespective of the negative externality this imposes on the composite good's profitability. A single regulatory agency with a comprehensive perspective, on the other hand, would not make such an oversight. The individual regulatory agencies "hold-up" the other players in the game, demanding excessive returns and reducing social efficiency.

For example, in a river-basin water management context, specific water quality standards may be required by a state Department of Natural Resources, E_1, with p_1 defined in detail to include, say, a two-year water quality study within specific parameters, conducted by state-identified engineers and overseen by an independent board of three approved professionals. Another regulatory agency meanwhile, E_2, defined perhaps as a local coastal commission, or the federal level Fish and Wildlife Service, may also be concerned with water quality, perhaps in the context of coastal ecosystem maintenance or fishery habitat concerns, and thus might independently require their own regulatory requirements, p_2, this time defined as a three-year water quality study with slightly different detailed parameters, conducted by a composite board of engineers and bioscientists, and approved by separate slate of professionals. Each regulatory agency demands satisfaction of its own particular terms; the marginal addition to water quality of these independent studies is minimal, while the overlap in effort grows. The composite price, p_q, becomes inefficiently high and production of q is stifled.

If water quality were instead monitored by a single regulatory agency alone, E_q, overlap and redundancies would be reduced and the composite price of regulation, p_q, would be lower. Graphically, the problem mimics the cost advantages embodied in moving to greater economies of scale production – Figure 1:



where

$$q_1 + q_2 = q^* \tag{7}$$

but

$$c_1(q_1) + c_2(q_2) > c^*(q_1 + q_2) \tag{8}$$

Production of q^* could occur along multiple independent cost curves, with their associated high prices, or it could occur along the lower, composite cost curve with its associated composite lower price.

Note in this example that it is multiple bureaucratic *perspectives*, not multiple agency *preferences*, that are causing the inefficiency. This bears repeating. That the state Department of Natural Resources and the local coastal commission are both concerned with water quality (i.e. the preference) is *not* the inherent problem; the essential problem is that there are multiple agencies (i.e. perspectives) that each address this valid environmental preference in a fragmented

and repetitive fashion. In other words, both p_1 and p_2 address water quality concerns, the problem is that they do so repetitively. The model above could easily be extended to incorporate multiple preferences as well as perspectives, such that each agency proposes a range of prices p_{ij} where j equals a set of preferences from water quality concerns to aquatic wildlife maintenance to aesthetic and historical preservation. We do not extend the model in this fashion here, however, because it would only serve to distract from the primary result that fragmentation of *perspectives* is what ultimately leads to the anticommons tragedy.[17] Inefficient scale is the problem we are focusing on in this paper, as distinct from competing priorities.

In other words, the environmental movement and its associated proliferation of regulatory monitoring agencies is not the problem per se, when it comes to issuing regulatory licenses and permits for the scarce river-basin water resources in the United States, the problem comes from the overlap of regulatory agencies monitoring similar goals and all having property rights to demand high regulatory approval prices to accomplish *similar sets of goals*. It is the redundancies in regulatory property rights that leads to the anticommons sclerosis and inefficiencies discussed in the paper. Another way to think about this is again in the cost curve sense. The cost curves of Figure 1 could theoretically be composed of costs on numerous necessary priorities, including capital, labor and land, or water quality, wildlife maintenance, and historical preservation. But that would just cloud the issue. We instead assume the cost curves are all representing a similar average numeraire. Then, the problem is less that multiple priorities exist, and more that they are independently agglomerated.

[17] In a model with diverse *preferences* as well as perspectives, the final outcome variable, q, involves a balancing of diverse j from a complex optimization problem. While important (Kosnik, 2010), this optimization problem is orthogonal to the one we focus on here, that of redundant perspectives.

Evidence

Tables 1 and 2 document the different regulatory agencies, at the federal and state levels, that have some degree of governing authority in river-basin water management in the U.S.[18] While comprehensive river-basin water management encompasses many diverse issues, for illustrative purposes we will concentrate in the following section on one aspect in particular: small scale hydropower (SSH).[19]

Small scale hydropower is a method for producing emissions-free, environmentally friendly renewable energy.[20] SSH facilities are run-of-river, meaning that the natural flow of the river is maintained and that they do not require a dammed reservoir in order to generate power. Without a permanent dam to block river flow, nor a large reservoir to flood arable land and disrupt river temperature and composition levels, many of the negative riverine effects of conventional (i.e. large) hydropower are avoided with a small scale hydropower plant. While there is still some inevitable disruption to portions of the streambed and riverbank in order to construct the small hydropower intake and generation facilities, with proper planning and effort these impacts can be quite minimal (ESHA, 2004). Indeed, the intake facility of a small hydropower plant is generally outfitted with trashracks and debris collectors, which serves an important cleansing function for the river itself (Kosnik, 2009). SSH, therefore, presents a win-win opportunity: renewable energy with no carbon emissions *and* a negligible local environmental footprint.

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[18] There are also local and county level regulatory agencies that were too numerous to document.

[19] SSH has been defined by the U.S. Department of Energy (2006) and others (The Bellona Foundation http://www.bellona.org/) as constituting generation capacities of 30 MW or less. This is not a universal definition, however, and some countries and organizations use the term small scale hydropower to refer to facilities generating 50 MW of power or less (Natural Resources Canada), or even 10 MW of power or less (Portugal, Ireland, Spain, Greece and Belgium, ESHA (2004)). In this paper the 30 MW or less distinction is assumed.

[20] There has been some debate over whether the reservoirs behind (large scale) hydroelectric dams emit greenhouse gas emissions and thus eliminate the "emissions-free" benefit of hydroelectric power, however recent research shows that this concern is geographically limited (HRW, 2008). Besides, the debate is largely irrelevant in any discussion of SSH as SSH by definition does not utilize large scale reservoirs.

Small scale hydropower has long been recognized for its environmentally friendly renewable energy potential (Brown and Ringo, 1979; USDOE, 1979, HEC and IWR, 1979),[21] and development of SSH is increasing on a global scale. The World Energy Council found that as of 2005 there were at least 4,525 MW of new capacity under construction, a 22% increase from existing levels (WEC, 2007).[22] Numerous countries have commissioned studies of their SSH potential in order to stimulate development, including Greece, Italy, Bulgaria, Romania, Austria, England, Scotland, China, and the U.S. (Antoniazzi, 2009; Forrest et al., 2008; Bacon and Davison, 2004; USDOE, 2004; Paish, 1998). China has built more than 43,000 SSH facilities in recent years (MNRC, 2004) and around the globe more than 100 other countries have constructed small hydro plants in the last few decades (Voros et. al., 2000). In the U.S., the potential for such development has been documented at least since the 1970s (USDOE, 1978; ELI, 1980a; 1980b; 1980c; 1980d; 1980e; 1980f; 1980g; FRC, 1980), and in 2004 the U.S. Department of Energy made an effort to comprehensively assess the domestic SSH potential by analyzing every two-mile stream segment across the United States for its head, flow, and generation potential and found that there were nearly 500,000 viable sites, capable of providing more than 100,000 MW of emissions-free electrical power (USDOE, 2004). Translated into actual emissions saved (and assuming this power is generated in lieu of fossil fuel based electricity generation (Kosnik, 2008)), this represents a reduction of 617 million metric tons of carbon emissions, or the removal of 66 million passenger cars from the road.

Yet since that study, and despite popular approval (Greenberg, 2009), SSH has had a difficult time getting off the ground in the U.S. Table 3 documents the number and rate of new

[21] Although other, additional benefits of small scale hydropower, including its reliability, decentralization, and domestic nature are only recently getting attention.

[22] The 4,525 MW is a conservative estimate because the World Energy Council defines SSH as plants with 10 MW or less of capacity (instead of 30 MW). Additionally, the report itself states that the SSH development numbers are an underestimate because not all countries made the effort to report SSH numbers.

SSH plants built in the U.S. between 1979 and 2007. The rate has clearly been decreasing. While there are a number of possibilities for the low rate of SSH development in the U.S., including environmental concerns, technological constraints, and high costs, these do not appear to be the driving factor behind the low rate of development. Many environmental interest groups, for example, support small scale hydropower (Village Earth,[23] Appalachian Mountain Club, Natural Heritage Institute, Union of Concerned Scientists, and others[24]) and a non-profit independent rating agency, the Low Impact Hydropower Institute, was created in 1999 by representatives from American Rivers, the Green Mountain Energy Company, and the Center for Resource Solutions to verify and certify the benign environmental effects of many SSH plants.[25] Technological constraints also do not appear to be the problem. The engineering behind hydroelectric power generation was first invented over one hundred years ago,[26] and while small scale hydropower does require modification to conventional (i.e. large scale) equipment, the technical ability to do so is understood and uncontroversial. This is unlike other renewable energy technologies such as solar, wind, geothermal, or hydrogen, which continue to undergo significant technological development and perfection even today. The input materials used to build SSH equipment are also conventional and readily available, unlike the silicon, for example, that creates production bottlenecks and price instability for solar power generation (Prometheus Institute, 2006). Finally, there exist competitive companies that produce the turbines and other equipment necessary to develop most small scale hydropower potential, and, this equipment is sturdy and reliable with turbine life spans lasting many decades.

[23] http://www.villageearth.org
[24] http://www.lowimpacthydro.org/content/supporters.aspx
[25] The Low Impact Hydropower Institute is primarily about impact, not size, and so they point out that size is not the only determinant for gauging a site's environmental impact (Grimm, 2002); mode of operation, age, and geographic location, for example, also matter. Size, however, often serves as a reasonable proxy for the facility's local environmental footprint.
[26] One of the first successful applications of hydropower in the United States was to light the city street lamps at Niagara Falls in 1881.

The lack of SSH development also does not appear to be about cost. In a recent cost-effectiveness study of the SSH potential in the United States, Kosnik (2009) found that there were hundreds of sites, across the United States, that cost less than $2,000 per kW to construct. This is a conservative figure that does not take into account the additional nonmarket benefits to hydropower such as reduced carbon emissions, reduced sulfur emissions, reduced fossil fuel imports, and greater national security. It is also a construction cost estimate, not a life-cycle cost estimate where the perspective on hydropower often turns out to be even more favorable given hydropower's long pay-back periods and below average maintenance and operation costs.

The lack of development of domestic small scale hydropower appears instead to be due to an overextended regulatory system composed of numerous, fragmented agencies (FERC, 2001). An example will make the point (Kamberg, 2005). In 1984 a hydro project in Idaho that was designed to generate 180 watts of power (its turbine-generator was small enough to attach to a kitchen faucet), and which would satisfy the energy needs of a nearby family home and avoid the utilization of a fossil-fuel based diesel generator, was denied regulatory approval. At different points over an eleven year process the Forest Service, the Corps of Engineers, the Idaho Department of Water Resources, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the Federal Energy Regulatory Commission were all involved. Initial application fees for the licensing process started at around $16,000 (in 1984 dollars) and this didn't include the fisheries, plant life, and historical grave studies additionally required, let alone the opportunity costs of the entrepreneur involved. In the language of the anticommons literature, each invested regulatory agency was a "rights-holder," capable of demanding individualized requirements, irrespective of the hold-up effects this had on the overall licensing

process. By remaining uncoordinated, these distinct rights holders exhibited negative externalities on each other and failed to achieve an optimal and efficient outcome.

Thirty years ago in a speech to the Small Scale Hydro Group, then FERC commissioner Georgianna Sheldon analogized the federal government's hydropower licensing mandate to a Spanish-American War monument when the pigeons leave; bulky, antiquated, and heavily encrusted with "judicial interpretation and legislative whimsy" (USDOE, 1980b). In thirty years, the cleaning crew has yet to arrive.

Where Do We Go From Here?

Theoretically, the anticommons tragedy exists because it is a game theoretic coordination problem without a socially optimal dominant solution. Legally, the anticommons tragedy continues to exist due to path dependency (Parisi et al., 2005; Heller, 1998; Brunetti, 1991). Rules involving statute of limitations, liberative prescritions, and rules of extinction for non-use all work to reconsolidate fragmented property rights holders, but rarely have these been applied, or perhaps even could be applied, in a regulatory setting.

In the small scale hydropower permitting context, the solution is to somehow coordinate regulatory authority in river system management in the U.S. to allow more integrated, comprehensive basin-wide assessments.[27, 28] Three types of reform are suggested, including: 1) structural reform that keeps existing rights-holders intact, but coordinates their actions through a lead agency, 2) organizational reform that consolidates, and thereby eliminates, some of the

[27] There is a danger that "comprehensive" powers could turn into monopoly powers. If this is a real threat one possible solution, as suggested by Dixit (2009), would be to have two (but only two) lead agencies that compete in any given instance for the right to the licensing powers, thus encouraging efficiency through regulatory competition.
[28] Note that many US states already regulate small business activity, through their local chamber of commerces, in such an optimally coordinated way. Small businesses often need multiple licenses and regulatory permits to begin production, and often they are able to get all this through their local chamber of commerce. When they are able to comprehensively satisfy their regulatory requirements from one place, this reduces the transaction costs involved in entrepreneurial activity, thus making overall business activity more organized and efficient.

disparate rights holders, 3) more modest reform that squeezes efficiency out of the current regulatory system through improved informational requirements and new legislative action. These three possible avenues for reform differ in their degree of practicality, efficacy, and radicalness, but they would all improve upon the current anticommons regulatory environment, and allow the U.S. to better respond to water management concerns and crises in the future.

Structural Reform:

The first possible type of reform would be to create a lead regulatory agency with primacy rights over river basin management issues. Such structural reform would not eliminate any current rights holders; the Fish and Wildlife Service, state Department of Natural Resources, the Federal Energy Regulatory Commission, and any other agency that currently claims a legal right to engage in river basin regulatory processes in the U.S. would maintain that right. The lead agency, however, would act as the coordinating authority through which all regulatory issues would pass and, if necessary, would have the power to arbitrate between competing claims and internalize any hold-up externalities from dilatory parties. Currently, no agency plays such a role, either at the federal or state level. The Federal Energy Regulatory Commission does coordinate the permitting process for SSH development, but they do not maintain undisputed primacy rights to resolve disagreements or alleviate anticommons tragedies, and outside of hydropower permitting, they do not have any obvious river-basin managment authority (FERC, 2001).

The identification of a lead river-basin regulatory agency would have many potential benefits. First, by coordinating information in a single place, it would allow better organization of any regulatory process, lowering transaction costs and improving communication throughout the stakeholders (USDOE, 1980b). A lead agency would also create knowledgeable and

experienced staff, dedicated to a regulatory procedure from beginning to end, thereby improving the continuity of any overall process (SBC, 2009; USDOE, 1980b). The creation of a lead agency also has the potential to reduce political rent seeking and the social welfare losses that attend it. When numerous agencies have the power to hold up any regulatory process, then numerous avenues exist for wasting time and resources trying to influence the disparate opinions; when the opportunity for overall control is solidified, the ability to engage in such diffuse rent seeking is reduced (Heller, 1998).

One potential criticism of this structural approach to reform is that the creation of a lead agency would only add yet another layer of bureaucracy to an already heavily encrusted bureaucratic system; in order to avoid this, a lead agency should not so much be created, as named. The Federal Energy Regulatory Commission, the Environmental Protection Agency, the Department of the Interior are all viable candidates, and they could each act as umbrella agencies, dividing up particular water management concerns if necessary to particular divisions, but maintaining overall responsibility for the regulatory process. Note that the concept of a lead agency also does not have to exist at the federal level. There could, on a different scale, be state level lead agencies that, at a minimum, coordinate bureaucratic processes within their state and from there integrate with federal agencies in a more streamlined way. Both Massachusetts and Wisconsin have considered versions of this in the past (USDOE, 1980b; ELI, 1980g).

Organizational Reform:

Another, more radical, type of regulatory reform would be to outright eliminate some of the duplicative, fragmented regulatory rights holders which weigh down the system today. Rather than keep all current rights-holders intact, but force them to defer to a lead agency, an alternative option is to eliminate overlapping bureaucratic rights-holders entirely. Such a reform

proposal would be politically difficult to implement, given that few rights holders would ever voluntarily accept a diminution of their claims.[29] But such reform is not impossible to implement either. Heller (1998) and Parisi et al. (2005) offer examples and legal precedence that exists for consolidating rights-holders once they have been detrimentally fragmented.

In the context of river-basin water management in the U.S., such organizational reform could focus at state or federal level primacy. In other words, the federal government could take over river-basin management responsibilities for the state and eliminate repetitive state agencies, or, the federal government could relinquish control and allow state agencies primacy over in-state river-basin water resources. This is similar to the way air and water pollution control is already handled in the U.S. today. It is overseen by a federal-level regulatory agency (the Environmental Protection Agency), but once approval by the EPA is given to a state-level pollution control plan, the state is left alone and responsibility for implementation is left to them. Something similar could be done for management of river-basin water use; with respect to SSH, for example, FERC could have the power to authorize a state-level hydropower licensing plan that met certain criteria, but after state-level approval was given, FERC and other federal agencies would get out of the way and practical implementation of the plan, including the specific licensing of SSH plants, would be left to the states.

Benefits to an organizational reform proposal that eliminates certain rights holders are that it would decrease transaction costs, decrease rent seeking, increase communicability and certainty of the regulatory process, and, in addition to improved outcomes, assign clear responsibility for failures in the process to particular agencies so that such failures are less likely to occur.

[29] This stickiness in reconsolidating rights-holders once they have already been fragmented is why Heller (1998) and others (Parisi et al., 2005) suggest that the Tragedy of the Anticommons is so difficult to overcome.

Modest Reform:

If both structural and organizational reform of current regulatory river-basin rights holders appears unlikely or impractical, a third option is to engage more modest reform aimed at squeezing inefficiencies out of the regulatory system as it exists today. The theoretical solution to any anticommons tragedy is to coordinate the perspectives of disparate rights holders, either through force (the lead agency concept), diminution of the number of rights-holders (organizational reform), or simply better communication, organization, and alignment of expectations of existing rights-holders. This more modest inefficiency-squeezing type of reform could entail, for example, the establishment of: 1) road maps and guidelines for particular regulatory processes, 2) easy access to information, expertise, counseling, and help, 3) draft contracts, standards, and template licenses, and 4) opt-in involvement defaults for all regulatory agencies. These reform efforts, explained in greater detail below, would help make expectations clear and reduce opportunities for regulatory overlap and confusion.

Guidelines: It would help if clear road maps for navigating particular regulatory processes were made available. Specific minimum requirements, pared of nonessential material and reduced of superfluous and repetitive documentation, would improve any regulatory process from SSH licensing to recreational permitting. These road maps for basic regulatory compliance could be made available along with clear timelines for completion, including document submittal and agency review (SBC, 2009). All of this would create long-term certainty, ease of use, and an improvement in coordination of the stakeholders involved.

Information: Easier access to information, expertise, counseling and help to navigate regulation and regulatory processes could be aided by better use of communication technologies. In the past couple of years FERC, the EPA, and other regulatory agencies have begun the use of

online documentation filing and distribution, but efforts at this type of IT reform could be increased. Many state level agencies do not have such electronic filing systems, and local stakeholders rarely have their information and knowledge organized in such a streamlined, easily accessible way. This lack of coordination leads to confusion and repetitive requests for information and studies, which bogs down and delays particular regulatory processes.

Standards: Along with road maps and guidelines, it would also help if regulatory filings were standardized and templates for particular regulatory processes were made available. For example, in the context of SSH, a tailored SSH license could be created proportionally designed for the low-scale needs of SSH development.[30, 31] Within this tailored SSH license, standards could be set that would cover emissions and other environmental impact requirements and which would specify testing procedures that would be used to verify compliance. Draft contract templates could be made available that spelled out the responsibilities of involved parties, liabilities, insurance and safety obligations, and other frequently relevant provisions. By standardizing the requirements and contracts involved in the SSH licensing process, and not leaving the details to be invented anew by fragmented, disparate stakeholders, uncertainty would be reduced, rent seeking diminished, the overall regulatory process streamlined, and efficiency enhanced. Of course, with any sort of standardization comes the tradeoff of reduced flexibility for dealing with site-specific concerns, but this tradeoff may be worthwhile. For regulatory procedures like SSH development, where the environmental impacts are by definition low, such a loss in site-specific flexibility may be worth the improved renewable energy outcomes that result.

[30] This would be distinct from the more involved, and more justified, lengthy requirements for large scale hydropower plants. Currently, the same licensing procedure is involved in permitting a 25 kW generator attached to a waterwheel on a stream, as is used in permitting a 500 MW facility on a major riverway (USDOE, 1980a).
[31] In 1978 FERC did try to introduce something like this in the form of a "short-form" license for small scale hydropower projects, but it was rarely used and eventually dropped off the radar screen.

Opt-in Default: Finally, one additional method of practically achieving modest reform would be to restructure the regulatory process from its current opt-out default, to an opt-in default for agencies that have a legal stake in the regulatory procedure. For example, after a SSH permit is submitted, any regulatory agency traditionally involved in the process would, rather than automatically becoming a stakeholder, have thirty days to respond to the initial permit application with an opt-in amendment. If they failed to respond, that would constitute a waiver of jurisdiction over that single particular regulatory procedure. Such a restructuring of the default involvement option would force timely, streamlined action on the regulatory procedure, as well as a likely concentration of stakeholder activity to only those parties most deeply invested. There is evidence in the economics literature in other contexts (Carroll et al., 2009; Benartzi and Thaler, 2007) that changes in such simple default involvement procedures can bring significant improvements in optimal outcomes.

Conclusion

This paper has extended the literature on complementary oligopoly and the tragedy of the anticommons to the regulatory sphere; it has developed the concept of the "regulatory anticommons" and shown how such a concept can be applied to river-basin water management in the U.S. Specifically, we looked at small scale hydropower development, but other river system management concerns, such as ecosystem protection, recreation development, and instream water banking, would likely also benefit from a regulatory anticommons appraisal. A worthwhile future research agenda would be to provide more empirically rigorous tests of this concept, in the river-basin water management context, or even others.[32] Other work could also

[32] For example, causal tests of regulatory agency fragmentation and, say, business licenses, patents, medical drugs, easements, building permits, nonprofit tax status', or hunting licenses approved.

investigate what *is* the efficient level of regulatory property rights. Where is the optimal balance between regulatory oversight at different levels and efficient resource utilization? None of the work represented here should be taken as a pro se argument for regulatory elimination; the due process of regulatory approval provides an important oversight function, but the question of how much regulation, and not simply whether or not to have regulation, is a much more difficult question to effectively answer, one which would benefit from increased thought and research.

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Table 1: Departments and Agencies at the Federal Level Concerned with River-Basin Regulation*

Advisory Council on Historic Preservation
Agriculture Department
Army Corps of Engineers
Bonneville Power Administration
Bureau of Indian Affairs
Bureau of Land Management
Bureau of Reclamation
Council on Environmental Quality
Delaware River Basin Commission
Department of Energy
Department of the Interior
Environmental Protection Agency
Federal Energy Regulatory Commission
Fish and Wildlife Service
Forest Service
National Oceanic and Atmospheric Administration
National Park Service
Northwest Power Planning Council
Southeastern Power Administration

* This list is not exhaustive.

Table 2: Departments and Agencies at the State Level Concerned with River-Basin Regulation*

	Agriculture	Boating & Waterways	Coastal	Ecology/ Biodiversity	Economic/ Regional Planning/ Development	Energy Management And Conservation	Environmental Protection/ Management/ Conservation	Fish and Game
Alabama	√				√		√	
Alaska					√		√	√
Arizona	√						√	√
Arkansas							√	√
California		√	√	√	√		√	√
Colorado	√					√		
Connecticut	√				√		√	
Delaware	√							
Florida	√				√		√	
Georgia	√				√			
Hawaii	√				√			
Idaho	√						√	√
Illinois	√				√		√	
Indiana					√		√	
Iowa	√							
Kansas	√							
Kentucky	√				√		√	
Louisiana	√				√		√	
Maine	√						√	√
Maryland	√				√		√	
Massachusetts	√				√	√	√	
Michigan	√				√		√	
Minnesota	√				√		√	
Mississippi	√				√		√	√
Missouri	√				√		√	
Montana	√						√	
Nebraska	√					√	√	√
Nevada								
New Hampshire	√				√	√	√	√
New Jersey	√				√		√	
New Mexico	√					√	√	√
New York	√				√	√	√	
North Carolina	√						√	
North Dakota	√							
Ohio	√				√		√	
Oklahoma	√						√	
Oregon	√					√	√	√
Pennsylvania	√	√			√		√	√
Rhode Island					√		√	
South Carolina	√							
South Dakota	√							√
Tennessee	√						√	
Texas	√				√		√	
Utah	√						√	
Vermont	√				√		√	
Virginia	√				√		√	√
Washington	√			√	√			
West Virginia	√						√	
Wisconsin	√							
Wyoming	√					√	√	√

	Forestry	Historical/ Heritage	Indian Affairs	Licensing and Regulation	Mines and Mineral Resources	Natural Resources	Parks and Recreation/ Tourism/ Culture	Public Health and Pollution Control
Alabama	√	√				√		
Alaska						√	√	
Arizona					√		√	
Arkansas	√	√					√	
California	√	√				√	√	
Colorado		√	√			√	√	√
Connecticut							√	
Delaware						√		
Florida	√							
Georgia	√					√	√	
Hawaii						√	√	
Idaho	√	√					√	
Illinois		√				√	√	√
Indiana						√	√	
Iowa						√	√	
Kansas	√	√					√	√
Kentucky		√				√	√	√
Louisiana							√	
Maine		√						
Maryland	√					√		
Massachusetts							√	
Michigan						√		
Minnesota		√				√	√	√
Mississippi	√	√						
Missouri						√	√	
Montana		√				√		
Nebraska		√				√		
Nevada						√	√	
New Hampshire							√	
New Jersey							√	
New Mexico				√			√	
New York							√	
North Carolina		√	√				√	
North Dakota		√	√				√	
Ohio						√	√	
Oklahoma							√	
Oregon	√						√	
Pennsylvania		√				√	√	
Rhode Island							√	
South Carolina	√	√				√	√	√
South Dakota			√			√		
Tennessee							√	
Texas		√		√			√	
Utah						√	√	
Vermont		√				√	√	
Virginia	√	√	√		√		√	
Washington						√	√	
West Virginia		√				√	√	
Wisconsin		√		√		√	√	
Wyoming							√	

	Public Service/ Public Utilities	Rural Services	State Lands	Port Authority	Transportation	Water Resources/ Management/ Conservation	Wildlife Conservation	Other
Alabama					√			√
Alaska					√			√
Arizona					√	√		√
Arkansas	√	√						√
California	√		√			√		√
Colorado	√				√			
Connecticut	√							√
Delaware	√							
Florida	√						√	√
Georgia	√					√		√
Hawaii	√		√					√
Idaho	√		√			√		
Illinois					√			√
Indiana	√							√
Iowa	√							√
Kansas								√
Kentucky	√							√
Louisiana								√
Maine	√							√
Maryland	√							√
Massachusetts								√
Michigan	√							√
Minnesota	√			√		√		√
Mississippi	√			√			√	
Missouri	√							√
Montana	√						√	
Nebraska	√							
Nevada	√					√		√
New Hampshire	√							
New Jersey	√							√
New Mexico	√		√					
New York	√							√
North Carolina	√						√	√
North Dakota	√		√			√		√
Ohio	√							
Oklahoma								√
Oregon	√		√			√		√
Pennsylvania	√							
Rhode Island	√					√		
South Carolina								√
South Dakota	√							
Tennessee	√						√	
Texas	√					√		√
Utah	√							√
Vermont	√					√		√
Virginia		√						√
Washington	√						√	√
West Virginia	√							√
Wisconsin	√							√
Wyoming	√					√		√

* This list is not exhaustive. Agency names may differ slightly at the state-specific level.

Table 3: New Small-Scale Hydropower Projects in the U.S., 1979-2007

Year	# Projects
1979	4
1980	3
1981	8
1982	5
1983	6
1984	8
1985	20
1986	31
1987	22
1988	11
1989	4
1990	11
1991	6
1992	7
1993	3
1994	0
1995	0
1996	1
1997	1
1998	1
1999	2
2000	2
2001	0
2002	1
2003	1
2004	1
2005	0
2006	1
2007	0

Source: Federal Energy Regulatory Commission e-library (http://www.ferc.gov/docs-filing/elibrary.asp)