Adaptive Management in Hydropower Regulation

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Editors' Summary

Hydropower dams play a critical role in the health of river ecosystems throughout the United States, and hundreds of these dams will be relicensed by the Federal Energy Regulatory Commission (FERC) in the coming years. Such licenses lock in the operating and environmental protection requirements of such dams for periods of up to 50 years. Given the complex, dynamic nature of river ecosystems, as well as the impacts of climate change, there is pervasive scientific uncertainty about how to best manage dams for power production while protecting and enhancing environmental values such as water quality and fisheries. Unless dams are managed adaptively, with licenses that provide pathways for gathering and applying new knowledge and responding to changing conditions, we run the risk of locking in mistaken approaches and stymieing environmental improvements on our rivers for the next half century.

Dams have drastically altered rivers throughout the United States, often transforming them from ecosystems regulated by natural forces into systems intensively managed by humans for power generation, flood control, and navigation. The resulting environmental harms are numerous. Dams physically cut off fish populations from habitat and spawning areas, while impoundment of water in reservoirs floods riparian forests. Alterations in the timing and quantity of flows dramatically change water quality by raising water temperature, turbidity, and algal growth; reducing dissolved oxygen levels, and increasing siltation, to name but a few effects.[1] Fisheries and other biological communities are completely altered or destroyed, and downstream recreational uses severely impaired.

Public values have changed greatly since the inception of federal hydropower regulation in 1920, and we are now in an era where few dams are built and there is a widespread interest in restoring river ecosystems and undoing some of the damage dams have caused. This Article concerns an important subset of the nation's dams, those privately operated hydropower dams regulated by FERC. FERC issues licenses for such dams that can lock into place the regulatory requirements for their operations for several decades at a time. Such a static approach is inconsistent with a contemporary understanding of ecosystems as dynamic, complex, and subject to considerable scientific uncertainty. This Article argues that adaptive management should be employed more widely in regulating these dams in order to build flexibility and learning into licenses and help restore river ecosystems.

In this Article, I will first describe the nature of adaptive management and the rationale for applying it to hydropower licensing. I will then provide a framework for describing and classifying the varying approaches to adaptive management. Although there is considerable variation among the different approaches, all are based on the goal of reducing the risks associated with forward-looking planning and decisionmaking under conditions of scientific uncertainty. However, in reducing the risks of scientific uncertainty, adaptive management often increases a variety of risks associated with regulatory uncertainty. Drawing upon licensing documents, published literature, and interviews with experts, I discuss these trade offs and how they affect the incentives of participants in hydropower licensing, and how they create challenges for implementation of adaptive management.

Author's Note: This Article was written prior to the author's employment with the U.S. Department of Justice and none of the views expressed are those of the Department. Any views expressed are those of the author.

1. Andrew H. Sawyer, *Rock Creek Revisited: State Water Quality Certification of Hydroelectric Projects in California,* 25 Pac. L.J. 973, 975 (1994); Trout Unlimited, Brief Amicus Curiae of Trout Unlimited et al., *in* Support of Respondent Maine Department of Environmental Protection (2006), 15-16.

I conclude by discussing the promise of adaptive hydropower licensing in light of these challenges.

I. What Adaptive Management Is and Why It Is Needed for Hydropower Licensing

A. Origins and Evolution of the Adaptive Management Concept

The concept of adaptive management originated in the late 1970s when ecologists began applying insights from economics, engineering, and the social sciences regarding organizational learning in the face of complex problems and uncertainty.[2] The idea of adaptive management has since become widely accepted among natural resource managers as a desired, albeit difficult to implement approach to managing complex natural resource systems in the face of scientific uncertainty.[3] The theory of adaptive management dovetails with ecological theory's embrace since the 1980s of a "non-equilibrium" view of ecosystems. Ecologists and resource managers developed an increasing appreciation of the complexity and stochasticity of ecological systems, the paucity of available data, and the inherent difficulty of formulating predictive models of the kinds employed in other branches of science.[4]

In the face of such pervasive uncertainty, adaptive management is intended to allow resource managers to respond to changing conditions and new information. Many environmental statutes, such as the Endangered Species Act (ESA),[5] take a prospective "front end" approach in which policies and decisions are fixed based on a preregulatory analysis. Scientists and regulators called upon to make such decisions often realized they faced incomplete information. One common response to such technical uncertainty is to base action on the "best judgment" of regulators or experts. Such an approach may be the best available, but also problematic if it does not incorporate the ability to learn from mistakes. Without such flexibility, one may be fixing in place the present mistaken biases of the expert community. In addition, decisions made in this manner are subject to political manipulation. The search for consensus is "vulnerable to value differences clothed as scientific dispute. Lack of consensus among experts often becomes a bar to action."[6]

In contrast, adaptive management is supposed to allow managers to monitor the results of their management actions, feed the data back into new analyses, and improve the regulatory measures over time.[7] An early proponent of adaptive management noted that "[p]rojects are inevitably experiments; the choice is to make them good ones or poor ones."[8]

The adaptive management concept has gained wide currency. Adaptive management is now a cornerstone of the U.S. Fish and Wildlife Service's (FWS') guidelines for developing habitat conservation plans (HCPs) for endangered species.[9] The U.S. Congress has mandated the use of adaptive management in the Florida Everglades ecosystem restoration program.[10] An extensive adaptive management program for the U.S. Bureau of Reclamation's Glen Canyon dam has been in operation since 1995 to mitigate adverse impacts upon the Grand Canyon National Park and Glen Canyon National Recreational Area.[11]

As adaptive management has moved from theory to practice, however, it has proven difficult to execute in the form originally envisioned. The theory of adaptive management called for management treatments or mitigation measures as controlled scientific experiments to test causal hypotheses about natural systems.[12] The instances where this theory has been successfully put into practice are few and far between. A recent survey of fisheries adaptive management programs noted various obstacles, including difficulty of overcoming presuppositions about the effectiveness of familiar management measures; reluctance of regulators to try risky experiments; the high cost of monitoring; breakdowns in institutional continuity and institutional memory; and bureaucratic inertia.[13]

Although adaptive management of the kind advocated by its original theorists is hard to implement, this has not stopped environmental regulators and managers from introducing adaptiveness in various forms and calling these efforts adaptive management even though they might depart significantly from what the original theory of adaptive management called for. In an attempt to account for this variability, the adaptive management literature today often distinguishes "active adaptive management" from "passive adaptive management."[14] Active adaptive management is the kind of adaptive management called for in theory, with its rigorous hypothesis-testing. In passive adaptive management, there will typically be monitoring and flexibility to change over time, but there will not be this same rigorous, hypothesis-driven approach to designing the initial management measures. I will discuss the differences between passive and active adaptive management in more detail later.

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2. A seminal work in the field is Crawford S. Holling, Adaptive Environmental Assessment and Management (1978). Regarding the evolution of the field, see National Research Council, Adaptive Management for Water Resource Project Planning 19 (Nat. Academies Press 2004) [hereinafter National Research Council].
3. Barry L. Johnson, *Adaptive Management—Scientifically Sound, Socially Challenged?*, 3 Conservation Ecology 1 (1999), *available at* http://www.ecologyandsociety.org/vol3/iss1/art10/.
4. *See* A. Dan Tarlock, *The Nonequilibrium Paradigm in Ecology and the Partial Unraveling of Environmental Law*, 27 Loy. L.A. L. Rev. 1121 (1994).
5. 16 U.S.C. §§1531-1544, ELR Stat. ESA §§2-18.
6. Kai N. Lee, *Adaptive Management: Learning From the Columbia River Basin Fish and Wildlife Program*, 16 Envtl. L. 431, 450 (1986).
7. *See* J.B. Ruhl, *Taking Adaptive Management More Seriously: A Case Study of the Endangered Species Act*, 52 Kan. L. Rev. 1249, 1252 (2004).
8. Lee, *supra* note 6, at 431.
9. *See* U.S. Fish and Wildlife Service, Habitat Conservation Planning Handbook (1996), *available at* http://www.fws.gov/Endangered/hcp/hcpbook.html.
10. National Research Council, *supra* note 2.
11. National Research Council, *supra* note 2, at 77-80.
12. Carl J. Walters, *Is Adaptive Management Helping to Solve Fisheries Problems?* 36 Ambio 304-07 (2007).
13. *Id.*
14. *See* National Research Council, *supra* note 2, at 21-23.

B. *Dam Management: The Promise and Limitations of Adaptation*

Rivers are complex ecosystems subject to a wide variety of human and natural influences. They support important biotic communities including fisheries, as well as human uses including recreation, navigation, and power production. Dams are often one of the primary influences on these ecosystems, and there is almost always considerable scientific uncertainty about their effects. In addition, there is considerable scientific uncertainty about the future hydrology of all rivers, given that climate change has the potential to radically change patterns of precipitation.[15] All of this suggests that dams should be managed adaptively so that their management can be refined over time in response to changing circumstances and new information.

Of course, there are limitations on how much can be accomplished by adaptively managing dams. One obvious limitation is the dam itself. A dam is a more or less permanent structure whose very presence alters the system. There are thus limitations on the environmental improvements one can achieve if physical removal of the dam is off the table. As I will discuss later, dam removal can be the "elephant in the living room" in negotiations over hydropower management; that is, a major but unspoken subtext. It must also be noted that virtually any river impacted by a dam will also be impacted by many other human impacts besides dams, including industrial discharges, flood control channelization, and runoff of sediment and pollutants due to construction, logging, and other land uses. Thus, adaptive management of dams may not be a "magic bullet" that would lead to recovery for an impaired river ecosystem.[16]

Nevertheless, dam operations can be manipulated in ways that produce significant environmental benefits. Flow timing is a particularly important issue with hydropower dams that hold large quantities of water behind a reservoir in order to time their release to coincide with periods of peak electricity demand, e.g. hot summer afternoons.[17] The quantity and temperature of water released affects fish habitat as well as the degree of flooding of downstream riparian areas. Dams present formidable barriers to fish migration, and turbines kill many of the fish that pass through them.[18] Thus, mitigation often focuses on fish passage, including the use of fish ladders, "trap and haul," and other means of helping fish to move to habitat above or below a dam. Dams can be reoperated to allow more natural patterns of downstream channel-scouring, transport of gravel, and floodplain inundation.[19] Dams that impound water behind a reservoir can be operated with selective water withdrawal structures that release deeper, colder water to benefit fish.

C. *The Need to Make FERC Licensing More Adaptive*

This Article primarily concerns the category of dams licensed by FERC, which consists of all nonfederal hydroelectric projects in the United States. Most of the dam-building in the United States occurred before the advent of the modern environmental movement, and now many of those projects are coming up for relicensing. Over the 30-year period from 2007 through 2037, the licenses were set to expire on 587 licensed projects.[20]

There are compelling reasons to employ adaptive management in such licenses. Most of the existing licenses were issued before the enactment of the federal Clean Water Act (CWA),[21] and likely contain "woefully inadequate" protections of fish, wildlife, and other environmental values dependent on water quality.[22] FERC and other regulatory agencies do not have the capacity to go out and gather all the scientific information needed in a relicensing, such as information about hydrology and the distribution and population dynamics of affected species. They rely on the licensee to develop and implement a study plan to characterize the baseline resources, predict how the project will affect them, and recommend management measures.[23] In most cases, initial hydropower relicensing applications do not include all the necessary scientific information about the impacts of the project, and FERC requests more information during relicensing proceedings.[24] However, the ability to modify the terms of the license will be far more limited once the new license has been issued.

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15. For example, the California Climate Change Center writes:

> If heat-trapping emissions continue unabated, more precipitation will fall as rain instead of snow, and the snow that does fall will melt earlier, reducing the Sierra Nevada spring snowpack by as much as 70 to 90 percent . . . even under wetter climate projections, the loss of snowpack would pose challenges to water managers [and] hamper hydropower generation . . . . Decreasing snowmelt and spring stream flows coupled with increasing demand for water resulting from both a growing population and hotter climate could lead to increasing water shortages.

California Climate Change Center, Our Changing Climate: Assessing the Risks to California 6-7 (2006), *available at* http://www.energy.ca.gov/2006publications/CEC-500-2006-077/CEC-500-2006-077.PDF.

16. *See* John M. Volkman, *How Do You Learn From a River? Managing Uncertainty in Species Conservation Policy*, 74 Wash. L. Rev. 719, 731 (1999).
17. Water releases to meet these periods of high electricity demand are sometimes called "peak" or "peaking" flows. *See, e.g.*, Brian D. Richter & Gregory A. Thomas, *Restoring Environmental Flows by Modifying Dam Operations*, 12 Ecology & Soc'y 1 (2007), *available at* http:www.ecologyandsociety.org/vol12/iss1.
18. It is difficult to generalize about how many fish are killed by turbines. Study results vary depending on fish species and turbine design, with larger fish suffering higher mortality than small fish or larvae. Mortality rates will be particularly high where fish pass through multiple turbines on rivers with more than one dam. Consequently, "[T]urbine mortality has been estimated anywhere from 0 to 100 percent." U.S. Office of Technology Assessment, Fish Passage Technologies: Protection at Hydropower Facilities 32 (1995).
19. *See* Richter & Thomas, *supra* note 17.
20. Data from Federal Energy Regulatory Commission (FERC), Hydropower web page, http://www.ferc.gov/industries/hydropower/gen-info/licensing/licenses.xls (last visited Aug. 27, 2009).
21. 33 U.S.C. §§1251-1387, ELR Stat. FWPCA §§101-607.
22. Interview with Brian Johnson, Trout Unlimited, Dec. 13, 2007.
23. Richard Roos-Collins, *Integrated Licensing Process: New Hope for Efficient Regulation of Nonfederal Hydropower Projects*, 35 ABA Trends (May/June 2004).
24. Of 157 relicensing applications filed in 1993, only nine provided sufficient scientific information about impacts, and the rest were subject to additional information requests from FERC. Hydropower Reform Coalition, Stranded Midstream: Cause and Consequence of Hydropower Regulatory Delay (Dec. 2001).

At the same time, FERC relicenses projects for a term of 30-50 years.[25] This means that any inadequate environmental protection and mitigation measures may be locked in place for many years once a license is issued or renewed. This constrains the ability to learn from experience and act on improvements in the state of knowledge regarding the effects of the dam and the effectiveness of mitigation measures. Furthermore, climate change virtually guarantees that many key assumptions about the operation of these natural systems made today will no longer hold true for the entire term of the licenses. While scientific uncertainty is pervasive in environmental regulation, the stakes are particularly high with these long-term hydropower licenses. In contrast, sewage treatment facilities, coal- and gas-fired power plants, and hazardous waste facilities are licensed on a five- or seven-year cycle.[26]

At this point, it does not appear that FERC is compiling information on how many projects are using adaptive management, or which ones.[27] However, FERC noted in 2006 that "adaptive management provisions are not uncommon in licenses issued in recent years . . . ."[28] This Article will review some examples of such licenses, analyzing the ways in which they attempt to be adaptive, and the strengths, weaknesses, and limitations faced by such efforts at adaptive hydropower licensing.

II. The Regulatory Context of Hydropower Licensing

The terms and conditions of hydropower licenses are set by FERC, but can also be shaped by federal fish and wildlife agencies and state governments. This section explains the regulatory mandates and powers of each.

A. FERC's Authority Over Licenses

Under the Federal Power Act (FPA), FERC has sole, preemptive authority to license nonfederal hydropower projects.[29] FERC's statutory mandate requires it to craft licenses that best serve multiple purposes. The license must contain conditions that will be

> [B]est adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water-power development, for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat), and for other beneficial public uses, including irrigation, flood control, water supply, and recreational and other purposes.[30]

FERC must give "equal consideration to the purposes of energy conservation, the protection, mitigation of damage to, and enhancement of, fish and wildlife (including related spawning grounds and habitat), the protection of recreational opportunities, and the preservation of other aspects of environmental quality."[31]

Fixing license terms for up to 50 years can make licenses rigid and inflexible rather than adaptive. FERC's standard license terms include reopener clauses in which FERC reserves authority to initiate proceedings to amend the license as required by the public interest.[32] However, these in themselves are not likely an effective tool for making licenses adaptive. The FPA says that FERC may not alter a license without the consent of the licensee,[33] a legal requirement originally created to help incentivize capital investments in dam-building. Thus, if FERC invoked its reopener clause, it would still lack authority to substantially change the license without licensee consent.[34] The full extent to which FERC could modify license terms under a reopener clause before it ran afoul of the FPA is probably an open legal question.[35]

FERC could also impose adaptive requirements in furtherance of its environmental protection mandates. FERC has acknowledged it has the authority to put adaptive management provisions into licenses, provided that the range of flexibility in these provisions is bounded to ensure that the license meets other, nonenvironmental requirements FERC judges to be necessary for the public interest.[36] For example, if a license contained adaptive provisions setting a range of possible flow values that could be varied in response to monitoring results, this would be permissible as long as range of possible flows did not go above or below the range required, in FERC's view, to serve FERC's nonenvironmental mandates such as power production or flood control. These boundaries are often referred to as "sideboards."

B. Authority of Agencies Other Than FERC to Impose Conditions on Licenses

Congress and the courts have gradually chipped away at FERC's sole and preemptive authority over hydropower

25. The length of the license term is tied to the amount of capital investment FERC requires of the licensee. FERC generally issues a 30-year term license for projects with little or no redevelopment, construction, capacity, or environmental mitigation or enhancement measures. If a moderate amount of such investment is required, the term is 40 years, and if extensive measures are required, the term is generally 50 years. FERC, Order Issuing New License, Pacific Gas and Electric Company, Project No. 2661-012, Issued Nov. 4, 2002, 101 FERC P 61165, 61672.
26. Hydropower Reform Coalition, Stranded Midstream: Cause and Consequence of Hydropower Regulatory Delay (Dec. 2001).
27. Interview with Timothy Welch, Supervisory Biologist FERC, Mar. 10, 2008.
28. FERC, Policy Statement on Hydropower Licensing Settlements, Sept. 21, 2006, at 18, *available at* http://www.ferc.gov/legal/maj-ord-reg/policy-statements.asp.
29. *See* First Iowa Hydro-Electric Coop. v. Fed. Power Comm'n, 328 U.S. 152 (1946).
30. 16 U.S.C. §803(a)(1).
31. 16 U.S.C. §797(e).
32. *See* 40 Fed. Reg. 51998 (Oct. 31, 1975).
33. 16 U.S.C. §799.
34. *See* Confederated Tribes & Bands of the Yakima Indian Nation v. FERC, 746 F.2d 466, 473, 14 ELR 20593 (9th Cir. 1984) ("Notwithstanding a reopener clause, FERC may not 'amend' a license in a modification proceeding without the licensee's consent.").
35. Interview with Michael Swiger, attorney, Van Ness Feldman, counsel for PacifiCorp and other hydroelectric licensees, Apr. 7, 2008, and Feb. 10, 2009..
36. FERC, Policy Statement on Hydropower Licensing Settlements, Docket No. PL06-5-000, 17-18 (Sept. 21, 2006).

licenses,[37] and now there are a variety of legal routes for other agencies to shape the license terms.

1. Authority of Other Federal Agencies

The FPA requires FERC to consider the recommendations of federal and state resource agencies, as well as those of Indian tribes affected by the project.[38] FERC must condition the license on the construction, maintenance, and operation of fishways prescribed by federal fish and wildlife agencies,[39] and must also accept any conditions imposed by federal land management agencies to protect the designated purposes of those federal lands.[40]

2. Authority of State Agencies Under CWA §401

State governments also have considerable power to shape FERC licenses. CWA §401 requires an applicant for any federal license or permit to obtain "certification" from the state for "any activity . . . which may result in a discharge to the navigable waters" of the United States.[41] The state's certification must confirm that any discharge from the project will comply with applicable effluent limitations and water quality standards under the CWA.[42] Such requirements become a condition of the federal license or permit.[43]

This state certification power under CWA §401 is quite expansive, due to the broad reach of water quality standards. The CWA requires each state's water quality program to adopt ambient water quality standards for all navigable waters "such as to protect the public health or welfare [and] enhance the quality of water."[44] States submit their water quality standards to the U.S. Environmental Protection Agency (EPA), which reviews them for consistency with the CWA.[45] Water quality standards consist of two parts, criteria and designated uses. Criteria are narrative or numerical standards for allowable levels of pollution. Typical numeric standards include hydrogen ion concentration (pH), temperature, concentrations of pollutants, and dissolved oxygen. Narrative criteria might prohibit objectionable odor, color, or turbidity, or the formation of putrescent bottom deposits.[46] Designated uses are beneficial uses that the water body will support if criteria are attained.[47] At minimum, state water quality standards must, wherever attainable, provide for protection and propagation of fish, shellfish, and wildlife and for recreation in and on the water. At the same time, water quality standards must take into consideration the use and value of public water supplies, agricultural and industrial uses, and navigation.[48]

The need to meet criteria and protect designated uses means that water quality standards can encompass virtually any human factor that influences a river. The §401 authority is thus potentially a very powerful tool in the hands of a state government that is willing to wield it assertively. In *PUD No. 1 of Jefferson County v. Washington Dept. of Ecology*,[49] the U.S. Supreme Court upheld state-imposed minimum flow requirements. The Court also held that states could use §401 to impose nonquantitative water quality standards that were expressed in "broad narrative terms" or were "open-ended."[50] The Court even acknowledged that §401 restrictions could encompass "aesthetic" concerns.[51] As Justice Clarence Thomas complained in his dissent, this gives states a virtual veto power in the FERC licensing process.[52] The *PUD No. 1* Court declined to clearly draw the boundaries of the §401 authority or comment on the limits of its grant of the power to enforce "any other *appropriate* requirement of State law."[53]

FERC has no discretion to reject a state's §401 conditions, and if it believes that issuing the license with such a condition violates its other statutory mandates, it has no choice but to refuse to issue the license.[54] Because the CWA gives states the authority to set water quality standards, and to make them more stringent than federal law, a licensee wishing to challenge a §401 certification requirement would have to do so in state court.[55]

C. Recent Trends: Negotiation and Heightened Environmental Restrictions

With more agencies (and their constituencies) playing a key regulatory role, it was probably inevitable that multiparty settlement negotiations would become increasingly important, and FERC now encourages the use of such negotiations in relicensing. FERC has been attempting to encourage a more collaborative approach since the late 1990s, in an effort to reduce costs, streamline the regulatory process, reduce controversy, and foster communication and collaboration among licensees, regulators, interest groups, and tribes.[56]

37. *See* Daniel Pollak, *S.D. Warren and the Erosion of Federal Preeminence in Hydropower Regulation*, 34 Ecology L.Q. 763-800 (2008).
38. 16 U.S.C. §803(a)(2).
39. 16 U.S.C. §811.
40. 16 U.S.C. §797(e).
41. 33 U.S.C. §1341(a); CWA §401(a). The original provision creating certification rights for states was §21(b) of the Water Quality Improvement Act of 1970, Pub. L. 91-224, s. 103, 84 Stat. 91, 108. In 1972, this was reenacted as §401(a).
42. 33 U.S.C. §1341(a)(1).
43. 33 U.S.C. §1341(d).
44. 33 U.S.C. §1313(c)(2)(A).
45. *Id.* §1313(c)(2)(A), (c)(3).
46. PUD No. 1 of Jefferson County v. Wash. Dep't of Ecology, 511 U.S. 700, 24 ELR 20945 (1994).
47. 40 C.F.R. §§131.2, 131.3(f).
48. 33 U.S.C. §1313 (2006); 40 C.F.R. §131.2.
49. 511 U.S. 700, 703, 24 ELR 20945 (1994).
50. *Id.* at 715-16.
51. *Id.* at 716.
52. Justice Thomas complained that the majority ruling left "no meaningful limitation on a State's authority under §401 to impose conditions on certification." *Id.* at 724.
53. *Id.* at 713 (quoting 33 U.S.C. §1341(d)) (emphasis added).
54. *See* American Rivers v. FERC, 129 F.3d 99, 28 ELR 20258 (2d Cir. 1997).
55. *See* Keating v. FERC, 927 F.2d 616, 622, 21 ELR 20692 (D.C. Cir. 1991).
56. *See* Interagency Task Force to Improve Hydroelectric Licensing Processes, Joint Statement of Commitment for an Improved Hydropower Licensing Process, *available at* http://www.ferc.gov/industries/hydropower/indus-act/itf/agree.pdf; FERC Office of Energy Projects, Report on Hydroelectric Licensing Policies, Procedures, and Regulations: Comprehensive Review and Recommendations Pursuant to Section 603 of the Energy Policy Act of 2000, 46, *cited in* Hydropower Reform Coalition, Citizen Toolkit for Effective Participation in Hydropower Licensing ch. 7 (2005), *available at* http://www.hydroreform.org/hydroguide/citizen-toolkit-for-effective-participation; *see also* Avinash Kar, *Ensuring Durable Environmental Benefits Through a Collabora-*

The negotiation-centered approach is increasingly supplanting the older Traditional Licensing Process. That approach is more of a notice-and-comment approach in which licensees publish draft documents, stakeholders submit comments, and administrative litigation ensues and "the general strategy is to win the paper war in the eyes of FERC."[57]

At the same time, environmental considerations have gained a higher profile in the current generation of relicensings. FERC has long been criticized for placing too great an emphasis on power production and too little emphasis on environmental protection.[58] However, since 1986, when Congress enhanced the role of environmental considerations in licensing, there has been an increase in the number of environmental protection conditions placed in hydropower licenses.[59] The commission has developed an "Integrated Licensing Process" that attempts to combine the relicensing process with NEPA review and other permitting processes and identify earlier in the process the data needs and develop a study plan to fill information gaps.[60]

FERC has had some success in responding to criticisms from both environmentalists and from licensees about the costs and inefficiencies of the licensing process. As one environmental advocate in such proceedings observed: "Relatively few [relicensing] decisions are appealed to court and most stakeholders believe that FERC today is doing a reasonably fair job of balancing energy and environmental quality."[61]

D. Multiple Agencies Could Impose Adaptive Management

In sum, the regulatory process provides several routes by which adaptive provisions could find their way into license requirements. One way would be for FERC to impose them after concluding they were necessary to meet its environmental mandates. Another way would be for federal land management agencies to impose them under their authority to place mandatory conditions in licenses to protect natural resources associated with the federal lands they manage. States could impose adaptive conditions under their CWA §401 authority. Nongovernmental stakeholders can urge these agencies to impose such conditions. The diversity of agencies that can impose adaptive management also means multiple points of entry for stakeholder groups to lobby. Where, as is often now the case, licenses are the product of multiparty settlement negotiations, these stakeholders can play an even more direct role in crafting license conditions.

III. A Framework for Analyzing Adaptive Management Programs

Before discussing the challenges and issues faced in designing adaptive management systems for hydropower licenses, it is useful to have a finer grained definition of what adaptive management is.

A. The Definitional Problem

The very term adaptive management has, for some practitioners, become discredited, or at least suspect, because it is used to describe so many different kinds of approach. There is a hazard that the use of a single term—adaptive management—will mask these important differences. Experts contacted for this Article almost invariably prefaced their comments with a disclaimer that different people use the term in different ways.

One source of ambiguity is the disconnect between theory and practice. The term adaptive management was coined to describe a hypothesis-driven use of management measures as scientific experiments. As already noted, practice has not always followed this model, leading commentators to distinguish between "active" and "passive" adaptive management. As will become clear later, this active/passive distinction is not sufficient to describe all the ways in which adaptive management programs can meaningfully vary. The existence of variation is, however, not reason enough to discard the term adaptive management. The term is still useful and meaningful for describing a family of varying approaches that share important resemblances and some overarching goals, even if there is not one set of specific traits that they all share.[62]

B. The Goal of Reducing Scientific Uncertainty

All adaptive management programs attempt to address the basic problem of reducing the risks of decisionmaking under conditions of scientific uncertainty. The greater the scientific uncertainty, the greater the greater risk that a decision will produce less than optimal outcomes. This risk can be reduced by learning, that is, by acquiring new information. Environmental decisionmaking and planning is often prospective or forward-looking, and often involves committing resources and legally fixing a course of action for many years to come. Issuing a hydropower license for a term of 30-50 years is a prime example.

The basic insight of adaptive management is that instead of making a single big decision at the outset, it is possible

tive Approach to Hydropower Re-licensing: Case Studies, 11 Hastings W.-Nw. J. Envtl. L. & Pol'y 27 (2004); American Whitewater, The Relicensing Process, http://www.americanwhitewater.org/content/Wiki/stewardship:relicensing_overview (last visited Feb. 19, 2007); *see also* 18 C.F.R. §4.34(i).

57. Richard Roos-Collins, *Integrated Licensing Process: New Hope for Efficient Regulation of Nonfederal Hydropower Projects*, 35 A.B.A. Trends (May/June 2004).

58. *See, e.g.,* Kurt Stephenson, *Taking Nature Into Account: Observations About the Changing Role of Analysis and Negotiation in Hydropower Re-licensing,* 25 Wm. & Mary Envtl. L. & Pol'y Rev. 473, 487-88. (2000); J.R. DeShazo & Jody Freeman, *Public Agencies as Lobbyists*, 105 Colum. L. Rev. 2217 (2005).

59. *See* DeShazo & Freeman, *supra* note 58; Michael R. Moore et al., *Testing Theories of Agency Behavior: Evidence From Hydropower Project Relicensing Decisions of the Federal Energy Regulatory Commission*, Land Econ., (Aug. 2001).

60. *See* FERC, Ideas for Implementing and Participating in the Integrated Licensing Process (ILP), Tools for Industry, Agencies, Tribes, Non-Governmental Organizations, Citizens, and FERC Staff (2006), *available at* http://www.ferc.gov/industries/hydropower/gen-info/licensing/ilp/eff-eva/ideas.pdf.

61. Roos-Collins, *supra* note 57.

62. The idea of family resemblances is often a useful alternative to the search for an all-encompassing definition of a term. As the philosopher Ludwig Wittgenstein noted, a word or term remains meaningful even if it encompasses a family of things that do not all share a single set of common characteristics, but instead exhibit a "network of similarities overlapping and criss-crossing . . . ." *See* Ludwig Wittgenstein, Philosophical Investigations, §§66-67.

to reduce the risks by breaking the big initial decision into a series of more incremental decisions spread out over time. During that period of time, one can make a systematic effort to acquire more information about the natural system and the effects of one's actions. With the benefit of this learning, this series of incremental decisions might be less risky than one large initial, irrevocable decision at the outset. My working definition of adaptive management, then, is that it is a system for phasing prospective environmental planning over a long period of time (decades). Furthermore, the system will incorporate the ability to generate, assimilate, and apply new information. Thus, a single high-risk, high-stakes decision made under great uncertainty becomes a series of lower risk decisions made upon an increasing (or at least up-to-date) base of information.

C. The Variable Parameters of Adaptive Management Programs

Although there is no single set of characteristics that all adaptive management programs share, they can be described according to a set of common parameters that can be implemented in varying ways. These parameters are: (1) the choice of an active or passive approach to designing management measures; (2) monitoring program; (3) feedback rules; and (4) oversight and decisionmaking authorities.

1. The Choice of an Active or Passive Approach to Design of Management Measures

As already mentioned above, discussions of adaptive management often distinguish between its active and passive forms. In active adaptive management, the management or mitigation measures are designed as controlled scientific experiments that will test a rigorously stated hypothesis. For example, an existing model might assume an untested relationship between springtime flow-volume and the number of salmon that spawn downstream of a dam. One could test such a hypothesis by increasing or decreasing flows during the time in question. It is even possible that the only way to test the hypothesis would be to alter flows in a way that harmed the salmon.[63] Scientific hypothesis-testing requires a controlled experiment. This means that testing the hypothetical relationship between springtime flows and salmon spawning would likely require gathering data about the effects not only of increased flows but a controlled comparison with a period in which flows were *not* increased, even if that were bad for the salmon population. Furthermore, other management measures that might help the salmon, such as improving the design of a fish ladder, could introduce a confounding variable by making it difficult to tell whether any gains in population were due to the flow experiment or the improved fish passageway. Thus, one might need to forego the better fish ladder to make the experiment work.

In a passive adaptive management approach, any number of other factors and considerations other than scientific hypothesis-testing might drive the design of the management or mitigation measures. These could include a best guess or consensus judgment of experts as to what measures are likely to produce the desired outcomes, perhaps informed by modeling. Or they could be the product of a negotiated compromise among stakeholders and regulators that factors in social and economic concerns, e.g., protecting electricity ratepayers or providing flood control; or mandatory legal requirements, e.g., contractual water rights, tribal rights, or ESA protections. But these measures would not be designed and implemented with the goal of scientific hypothesis-testing.

2. Monitoring Program

Anything that receives the label adaptive management inevitably has some monitoring component, because it is not possible to learn without monitoring environmental conditions. In the hydropower context, typical variables to be monitored would include things like fish population size and distribution and water quality. Of course, monitoring programs may be more or less well-designed, more or less well-funded, and more or less well-implemented. Different adaptive management schemes also vary in terms of how monitoring is integrated with decisionmaking, as discussed below. In other words, there is the question of who uses the monitoring data and for what purposes.

3. Feedback Rules

Since the goal of adaptive management is to spread out decisionmaking over time to reduce risk, virtually anything called adaptive management will feature some feedback rules governing how new information or learning is supposed to trigger management changes. This can take varying forms.

In some cases, an adaptive management system defines in advance specific monitoring thresholds, and specifies in advance how the system will change in response to these triggers. For example, managers might experiment with a particular water-release schedule, and if fish populations or water quality declined below predefined quantitative thresholds, this could automatically trigger a predefined increase in flow levels. Alternatively, crossing the thresholds might not trigger predefined actions, but would trigger a reevaluation by decisionmakers with the authority to order changes they deemed appropriate. In some adaptive management systems, the feedback rules are looser, and there are no predefined thresholds or triggers at all. The rules might simply specify a monitoring program and reserve in some decisionmaking authority the ability to make changes based on its evaluation of new information or changed circumstances.

In many cases, the feedback mechanism is constrained by predefined limits, referred to in the FERC licensing context as sideboards. Sideboards limit the range of action the decisionmaking authority has to respond to the feedback it gets from the monitoring and analysis. For example, where adap-

63. *See, e.g.,* John A. Volkman & Willis E. McConnaha, *Through a Glass, Darkly: Columbia River Salmon, the Endangered Species Act, and Adaptive Management*, 23 Envtl. L. 1249, 1256-57 (1993).

tive management sought to vary a dam's water releases, sideboards might place limits on the amount of additional flows that could be required in the future.

The feedback rules should also include rules for how data is evaluated and how decisions will be made. This raises the question of who will make decisions. The program might, or might not, call upon the decisionmaking authority to carry out a formal reevaluation of the current management measures on a defined schedule, e.g., annually, every five years, etc. The program might create a new decisionmaking entity, which raises questions about how that entity will be structured and funded, a topic that I discuss below.

4. Oversight and Decisionmaking Authorities

Since adaptive management requires many years of organized effort, there must be authorities that persist over time to carry out oversight and decisionmaking functions. Oversight includes ensuring that the monitoring is carried out, implementing the feedback mechanisms, and enforcement if parties fail to carry out their obligations. A decisionmaking authority will likely be needed to decide when adaptive changes in management measures are required, and what these changes should be. Finally, since adaptive management programs are designed to run for many years, another set of questions will concern how these authorities are constituted and funded in order to ensure continuity and preservation of institutional memory.

D. The Trade Offs Between Scientific Uncertainty and Regulatory Uncertainty

Adaptive management creates trade offs between two kinds of uncertainty. On the one hand, adaptive management tends to reduce the risks associated with scientific uncertainty by incorporating monitoring and learning into management. On the other hand, it tends to increase regulatory uncertainty by leaving the exact nature of future management measures more open-ended.

There are a variety of risks associated with the two kinds of uncertainty. As a result, there is no single answer to the question of whether a licensee, stakeholders, or a regulator will tend to favor adaptive management. It depends on how these risks and trade offs are viewed in the particular circumstances. The following table summarizes the categories of risk associated with each form of uncertainty, scientific and regulatory, and how risks change as a license is made more flexible. By flexibility, I refer to the fact that in adaptive management, there is less certainty at the outset over the precise operating requirements and mitigation measures that will be required of the licensee in the future, and these are more subject to change over time. A license that is more specific at the outset and less flexible tends to increase the risks of acting under scientific uncertainty (indicated by upward arrows); a more flexible, "adaptive" license tends to decrease those risks (downward arrows). But more flexibility tends to increase the risks associated with regulatory uncertainty. The various categories of risk will be applied and discussed in more detail in the next section.

	Risks of Acting Under Scientific Uncertainty and Who Bears Risk	Risks of Acting Under Regulatory Uncertainty and Who Bears Risk

License Less Flexible/Less Subject to Future Change	RISK ↑
	• Licensees:
	  • Overspending on protection
	• Regulators, environmental stakeholders
	  • Underspending on protection
	  • Ineffective actions
	  • Harmful actions
	• All Parties:
	  • Failure to learn from experience
	  • Difficult to respond to changed circumstances
		RISK ↓
		• Licensees:
		  • Inaccurate cost/benefit projections
		  • Future requirements arbitrary
		  • Hidden environmentalist agendas
		• Regulators:
		  • Institutional continuity-changing funding and capacity levels
		  • Compliance failure
		  • Legal uncertainty
		• All Parties:
		  • Institutional continuity-changing players and understandings

License More Flexible	RISK ↓ Same types of risks as above	RISK ↑ Same types of risks as above

I will discuss the items in this table in more detail below. But a few examples will help clarify the framework. Where a license is less adaptive, and all the terms and conditions are fixed for the next 30-50 years, the risks of acting under scientific uncertainty go up. There is a risk to licensees that regulators acting under this uncertainty will demand greater expenditures on environmental protection than were actually optimal. Regulators face the risk that they will ask for too little in the way of environmental protection, or that the mitigation measures they require will be ineffective or harmful to the environment.

On the other hand, the nonadaptive license has lower risks associated with regulatory uncertainty. Licensees are better able to forecast revenue streams from power generation and determine whether continued operation is profitable. Licensees may fear that a flexible, adaptive approach will allow regulators to impose arbitrary future requirements, or might be a vehicle for a hidden environmentalist agenda of driving up costs to force eventual dam removal.

Regulators also may benefit from reduced risks of regulatory uncertainty. Compliance monitoring and enforcement will likely be simpler where the license terms are fixed. These become more complex where the regulators must maintain active involvement in the oversight of an adaptive monitoring program, and participate in decisions about how to modify the mitigation measures over time. An agency that commits to an adaptive management program runs the risk that in future years it will lack the institutional capacity, perhaps due to funding or personnel changes, to continue to effectively participate in the program. All parties also bear the risk that adaptive requirements are less specific and more open to future interpretation, and thus that future actors may understand the implications of the adaptive management rules differently than current players.

IV. Adaptive Management in the Hydropower Context

In this section, I will apply the above framework to discuss the issues and challenges that arise when implementing adaptive management in hydropower relicensing. First, I will address the general question of how the decision to make a system adaptive, flexible, and changeable affects risks and incentives. Then, I will explore the four basic parameters of how an adaptive management system is designed: (1) the choice of an active or passive approach to design of management measures; (2) monitoring program; (3) feedback linkages; and (4) oversight and decisionmaking authorities. I will discuss how choices about setting these parameters affect the trade offs between risks from regulatory and scientific uncertainty; how these trade offs influence the parties involved in negotiation or regulatory decisionmaking; and how these trade offs reflect deeper underlying challenges in implementing adaptive management.

A. *To Adapt or Not Adapt: Pros and Cons of Flexibility*

Both passive and active adaptive systems are likely to make the initial management measures more provisional, more flexible, and subject to future change. As noted already, this tends to reduce the risks associated with initial scientific uncertainty, while raising the risks of regulatory uncertainty.

1. Advantages to Flexibility

I have already discussed the basic advantages of flexibility in terms of the ability to learn, use new information, and respond to changing conditions. Flexibility also reduces the risks from certain kinds of uncertainty. It can reassure regulators and environmental stakeholders that the adopted protection measures can be made effective over time despite present scientific uncertainty. It can also reassure licensees that the adopted measures are not excessive.

The flexibility of adaptive management may also facilitate negotiation to reach a licensing settlement. Adaptive management provides a way to hedge bets as to what protective measures will ultimately be required. It gives licensees something they can offer in lieu of the most risk-averse, costly environmental protection requirements that might otherwise be demanded. It gives environmental regulators and stakeholders the opportunity to revisit decisions they might fear will be faulty if based only on present-day data. More generally, in negotiations, it is "easier to agree on a range than zero in on a particular value" when parties to a negotiation disagree on things like flows or mitigation funding.[64] As the National Research Council noted in a study of adaptive management programs: "Adaptive management can help reduce decision-making gridlock by making it clear that decisions are provisional, that there is often no right or wrong management decision, and that modifications are expected."[65]

2. Risks From Flexibility and Regulatory Uncertainty

Hydropower licensees will, in many instances, find worrisome the regulatory uncertainty created by an adaptive approach. Regulatory uncertainty directly affects their bottom line, because electricity generation is directly tied to how much water can be stored and when it can be released through the turbine. Uncertainty as to future environmental restrictions make it difficult for dam operators to predict revenues and costs and determine that their project will be profitable and cost effective for ratepayers.

State and federal agencies that enforce environmental and natural resource protections may also sometimes prefer, for their own reasons, to avoid regulatory uncertainty. As noted already, several such agencies have the legal authority to place mandatory conditions into hydropower licenses. Choosing between regulatory certainty and scientific certainty can be

64. Interview with Timothy Welch, Supervisory Biologist, FERC, Mar. 10, 2008.
65. National Research Council, Adaptive Management for Water Resources Project Planning 20 (2004).

a "delicate balance."[66] In the face of considerable scientific uncertainty, a regulator might opt to adopt the most environmentally risk-averse, costly protections and lock them into place at the outset.

Another reason for regulators to shy away from adaptive management is legal uncertainty. Although there is now a track record of hydropower licenses with adaptive terms, adaptive management must still be considered an innovation, given that hydropower licenses are supposed to run for a period of 30-50 years. Open-ended adaptive provisions could be challenged in court. For example, in *Commonwealth Power Company v. Department of Natural Resources*,[67] the Michigan Department of Natural Resources ordered a hydropower licensee to conduct a fish entrainment[68] and mortality study as a condition of receiving §401 certification.[69] The Michigan Court of Appeals overruled this requirement on the grounds that the defendant

> [W]as not *imposing a requirement that it knew would be necessary to protect fish in the river*. . . . [D]efendant did not order that plaintiff comply with certain conditions to ensure that fish kill in the river would be low. Instead, it simply wanted plaintiff to conduct an *exploratory* study regarding the number of fish killed. . . . [D]efendant did not know or did not express what level of fish kill was acceptable or what type of protective measures were necessary to maintain the proper "use" of the particular river for particular species of fish.[70]

In other words, a state court might find adaptive management requirements to not have a direct enough connection between the requirements imposed and the achievement of a clearly defined environmental goal or compliance with a clearly specified legal standard.

A scientist who worked on an adaptive management program for the relicensing of dams on the Lower Roanoke River (discussed further in a later part of this Article) noted that state water quality authorities were initially quite averse to the legal risks of adaptive management and "highly disinclined to be creative" with the §401 conditions.[71] He also observed that in successful examples of adaptive management,

> agencies with regulatory authority seldom proposed or initially supported adaptive strategies. Stakeholder organizations without regulatory authority and essentially without official mandate in the processes beyond the right of the public to provide input pressed hard for adaptive management agendas and, in the absence of tested and reliable intraagency alternatives, the regulatory agencies accepted these proposals.[72]

Of great importance also is FERC's aversion to regulatory uncertainty. This will limit not only FERC's willingness to impose flexible, adaptive license terms, but will also limit the ability of settlement negotiations to make licenses flexible, since all settlements must be approved by FERC. FERC and its predecessor agency, the Federal Power Administration, originally had strong, single-minded mandates to promote hydropower development.[73] The FPA's hydropower provisions were part of a Progressive-era initiative to centralize and promote hydropower development, and to give FERC sole and preemptive authority in this area.[74] The effects of this history linger, and FERC has often been criticized for placing too great an emphasis on power production and too little emphasis on environmental protection.[75] The original purpose of 50-year license terms was to provide regulatory certainty and encourage large capital investment in the construction of dams, and it is still part of the mandate and the institutional culture of FERC to seek certainty for licensees.

Thus, FERC has rarely invoked the reopener clauses it puts in all licenses, a fact that likely contributed to the desire of resource trustee agencies and state regulators to begin imposing more flexible, adaptive requirements themselves.[76] FERC has stated in its official policy on licensing settlements that its reopeners

> are only exercised where environmental conditions have significantly changed. Were the Commission to assert a broad, general authority to reopen any part of a license during its term . . . this would sharply undercut the certainty sought by parties to licensing proceedings . . . the Commission's role in overseeing license compliance makes it important that license conditions be clear and enforceable."[77]

FERC has, however, attempted to accommodate the adaptive approach while limiting the resulting regulatory uncertainty. FERC generally insists that adaptive hydropower licenses incorporate sideboards that limit the possible range of possible changes, for example limiting the amount of additional flows that might be required later. Similarly, the licensee might be required to establish a mitigation fund for a limited amount that will be used adaptively. For example, the program might set up at the outset a fund of $10 million to spend on habitat restoration, and the adaptation would involve decisions about how to allocate the funds, while the licensee would have certainty about the cost.[78] However, limiting the regulatory uncertainty in this way also limits the effectiveness of the system when it comes to reducing the risks of scientific uncertainty. There is, for example, the risk

66. Interview with Paul DeVito, Oregon Department of Environmental Quality, Mar. 30, 2008.
67. Nos. 204399 & 210844, 2000 Mich. App. LEXIS 2465 (Mich. Ct. App. Mar. 21, 2000).
68. "Entrainment" refers to fish being caught up in the pumps or other works of a dam or other water project.
69. Commonwealth Power Co., 2000 Mich. App. LEXIS 2465, at *7.
70. *Id.*
71. Interview with Sam Pearsall, Director of Science and Roanoke River Project Director, The Nature Conservancy, May 1, 2008.
72. Susan L. Manring & Sam Pearsall, *Creating an Adaptive Ecosystem Management Network Among Stakeholders of the Lower Roanoke River, North Carolina, USA*, 10 Ecology & Soc'y 16 (2004).
73. Iowa Hydro-Electric Coop. v. Fed. Power Comm'n, 328 U.S. 152, 180 (1946).
74. *Id.* at 176, 182.
75. *See, e.g.,* Kurt Stephenson, *Taking Nature Into Account: Observations About the Changing Role of Analysis and Negotiation in Hydropower Re-licensing*, 25 Wm. & Mary Envtl. L. & Pol'y Rev. 473, 487-88. (2000); DeShazo & Jody Freeman, *supra* note 58.
76. Swiger, *supra* note 35.
77. FERC, Policy Statement on Hydropower Licensing Settlements, Sept. 21, 2006, *available at* http://www.ferc.gov/legal/maj-ord-reg/policy-statements.asp.
78. Swiger, *supra* note 35.

that the sideboards will be set too restrictively and that the natural resources will not be protected when a problem is discovered later.

3. Is Adaptive Flexibility Just Letting the Licensee Off the Hook?

Adaptive management has been subject to strong criticism in the context of the ESA, for shortcomings such as failing to design measures as experiments, failing to properly fund monitoring, and for giving regulated parties too much—in particular, for trading the right to harm endangered species for "ill-considered agreements between agencies and developers that evade the ESA's otherwise strict prohibitions."[79] In effect, regulators are accused of postponing difficult decisions and merely pushing into the future the need to address scientific uncertainty. And they are accused of trading away too much by issuing incidental take permits in situations where scientific uncertainty prevents them from designing adequate mitigation and protection measures at the outset. The result of such failures can be allowing development projects to proceed that would not otherwise be permitted, and letting developers off the hook for endangered species protections in exchange for vague and unfulfilled promises of future adaptation.

Adaptive management in hydropower licensing could lead to similar failures to follow through on promises of monitoring and scientific learning. However, the danger of employing adaptive approaches is not the same in the hydropower context. For one thing, adaptive management in the endangered species context is often used in the context of permitting irreversible changes in land use that cannot occur without ESA incidental take permits. In contrast, with hydropower relicensing, the dams already have been built—the question is not whether they should be built, but what to do with them. While it is possible to decommission and remove dams, that is, in itself, a costly process, in some cases prohibitively costly or infeasible for other reasons. Thus, adaptive management of dams sets up less of a danger that regulators will use adaptation as an excuse to "give away the store."

Furthermore, adaptive management under the ESA is used in the context of HCPs whose overall purpose is to enhance the flexibility of otherwise strict incidental take prohibitions. In contrast, adaptive management in the hydropower context would not generally take the place of prohibitions on environmental harm, but would rather just make the inevitable compromises between hydropower production, environmental protection, and other FERC mandates more flexible and subject to revision over time.

4. Regulatory Certainty Versus Flexibility on the Klamath

Recent negotiations over relicensing of hydropower dams on the Klamath River provide an example of the risk of trade offs between scientific and regulatory certainty, and how different parties perceived these risks. The Klamath case illustrates that whether flexibility is favored may depend on factors such as trust and bargaining power as well as economic costs. Although the regulatory certainty of fixed license terms is often portrayed as a boon for licensees, there are circumstances where licensees will favor more flexibility and regulators will embrace the certainty of front-loaded licenses.

On the Klamath River, which straddles the California-Oregon border, relicensing negotiations for PacifiCorp's hydroelectric projects were highly contentious. In fact, after relicensing negotiations reached an impasse, the parties reached a tentative settlement that would lead to tearing down these dams with partial public funding rather than continuing to operate them for power generation.[80] One of the sticking points in the relicensing impasse was a disagreement over whether it was better to build costly new fish passage structures or experiment with less costly fish passage measures employing an adaptive approach. Exercising their authority to impose mandatory fishway prescriptions, National Oceanic and Atmospheric Administration (NOAA) Fisheries and the FWS demanded fish passage facilities that could have cost $300-400 million.[81] To some extent, these costly demands were the result in a breakdown in negotiations and trust between the agencies and the licensee. Managers in the agencies felt that the licensee was not conducting in good faith requested prelicensing studies that were needed to reduce scientific uncertainties about fisheries-related issues when the relicensing proceedings began five years ago. These included studies on fish entrainment, predation, passage through reservoirs, and passage through dewatered bypass reaches. Without this information, the agencies felt they could not tailor very specific fishway prescriptions, and would apply the precautionary principle in the absence of the information that such studies would produce.[82]

PacifiCorp, not surprisingly, took a different view of the situation. It advocated a "gradualist," adaptive management approach, saying that it did not make sense to spend hundreds of millions of dollars just to "see what happens."[83] A subtext of the Klamath River negotiation was the desire of some stakeholders, and possibly some regulators, to make mitigation measures so expensive that it would be more cost effective to remove the dams than to operate them. Dam removal is often an "elephant in the living room" in hydropower negotiations. Licensees and other stakeholders sometimes believe that environmentalists who are calling for

79. Alejandro E. Camacho, *Can Regulation Evolve? Lessons From a Study in Maladaptive Management*, 55 UCLA L. Rev. 293 (2007); *see also* Daniel Pollak, The Future of Habitat Conservation? The NCCP Experience in Southern California, California Research Bureau (2001), *available at* http://www.library.ca.gov/crb/01/09/01-009.pdf.

80. Jeff Barnard, Associated Press, *Tentative Deal Will Clear Klamath River for Salmon*, The Oregonian, Nov. 12, 2008.

81. Interview with Scott Williams, Alexander, Berkey, Williams & Weathers LLP (Mar. 31, 2008).

82. Interview with David White, NOAA Fisheries, Feb. 28, 2008; E-mail from David White, May 15, 2009.

83. Swiger, *supra* note 35.

tighter regulation of dam operations are actually pursuing a hidden (or not-so-hidden) agenda of dam removal.[84]

The adaptive management plan recommended by PacifiCorp, and selected by FERC in its environmental impact statement preferred alternative, would have initiated studies and a trial program to reintroduce fish above the J.C. Boyle Dam using "trap and haul" rather than building more costly fish passageways into the dam.[85] At the same time, the licensee would have performed studies to reduce scientific uncertainties about the potential for restoring anadromous fish above the dam. If the studies found it feasible, a more ambitious trap-and-haul program would be initiated.

This proposal would have been a form of passive adaptive management, since it would amount to taking a try-and-see approach with trap-and-haul, as opposed to the fishery agencies' more costly try-and-see approach with building fish passage structures such as fish ladders. NOAA Fisheries was unwilling to accept this proposal, which had several defects. If the trial trap-and-haul programs were unable to establish sustainable populations above the dams, and studies were unable to determine the reasons for these failures, then PacifiCorp's responsibilities apparently would have been at an end. Similarly, it was not clear what the licensee would be required to do if the reason for this failure turned out to be that trap-and-haul was simply not effective enough. No pathway in this program appeared to require the licensee to ever implement the more expensive fish passage measures demanded by the fishery agencies.

With negotiations such as these and other issues at a stalemate, the stakeholders announced a settlement deal that would lead to the removal of the disputed dams.[86] The agreement calls for a federal assessment of the costs and benefits of removal, to be completed by 2012, and if the results are favorable, the parties would set a target date of 2020 for completion of the removal project.[87] PacifiCorp ratepayers would contribute $200 million to the cost, and $250 million would be paid by a California bond issue.[88] Evidently, PacifiCorp believes that its costs will be less than the costs it would have faced to operate the dams under a new license incorporating the federally mandated environmental measures.

The dispute over adaptive management on the Klamath River is analogous to one reported in *Confederated Tribes & Bands of the Yakima Indian Nation v. FERC*,[89] in which FERC approved a license on the Columbia River for the Chelan County Public Utility District. FERC issued a 40-year license without properly consulting the National Marine Fisheries Service over fishery requirements. FERC argued that fish protection needs were met by a preexisting requirement that the licensee conduct a study of the effects of this and related projects on the fishery, along with inclusion of a reopener clause that would permit FERC to impose fish protection measures later. The U.S. Court of Appeals for the Ninth Circuit ruled that fishery issues must be analyzed prior to licensing, and could not be deferred only on the promise of further study and the possibility of new proceedings.[90] The court noted that allowing fishery issues to be deferred reduced the incentive of the licensee to resolve these issues as quickly as possible, and the licensee "may very well attempt to forestall the imposition of protection measures because these might affect the project's power production."[91]

The debate over adaptive management on the Klamath River illustrates how it may be the licensee, rather than the regulators, that seeks flexibility rather than regulatory certainty. Much obviously depends on relative bargaining power. As already noted, federal land management and fish and wildlife agencies, as well as state water quality agencies, have the power to put mandatory terms into FERC licenses. If they decide to employ that power aggressively to impose costly conditions, there is little, in terms of legal rights or authority, that FERC or the licensee can do to block this. Licensees do, however, sometimes bring considerable political clout to licensing negotiations. For example, a company whose dam provides electricity for a nearby city will likely arrive at the negotiating table with the city itself as a powerful ally.[92] Where there is a conflict between FERC and another federal agency, as in the Klamath River example, the resolution may depend as much on the relative influence of the two agencies at the political level in Washington, D.C., as it depends on their respective legal powers. If a licensee has sufficient bargaining power, environmental regulators or stakeholders may need to be prepared to give something up in order to win an adaptive management program. They might, for instance, have to offer the possibility that, at least at the outset, flow conditions would be less favorable to the environment and more favorable to electricity generation than they might otherwise seek to impose by fiat.[93]

On the Klamath River, PacifiCorp portrayed itself as the advocate of the scientific method. It characterized its adaptive management approach as a reasonable, incremental approach to dealing with scientific uncertainty and avoiding the risk of over-costly or wasteful protection measures.[94] NOAA Fisheries, in contrast, portrayed the proposal as simply "using an adaptive management scheme to defer information collection and basic licensing decisions until after the license is issued," which it termed "unacceptable."[95] This illustrates

84. Interview with Sam Pearsall, Director of Science and Roanoke River Project Director, The Nature Conservancy, May 1, 2008.
85. *See* PacifiCorp, PacifiCorp's Alternative to the Joint United States Fish and Wildlife Service and National Marine Fisheries Service Preliminary Fishway Prescriptions, Attachment A: Anadramous Reintroduction Plan; and FERC, Final Environmental Impact Statement for Relicensing of the Klamath Hydroelectric Project No. 2082-027, Nov. 16, 2007, 2-30–2-31.
86. *See* Jeff Barnard, *Tentative Deal Will Clear Klamath River for Salmon*, The Oregonian, Nov. 12, 2008.
87. U.S. Department of the Interior, *Agreement in Principle Marks First Critical Step on Presumptive Path to Remove Four Klamath River Dams*, news release, Nov. 13, 2008.
88. Barnard, *supra* note 80.
89. 746 F.2d 466, 468, 14 ELR 20593 (9th Cir. 1984).
90. *Id*. at 471-73.
91. *Id*. at 473.
92. Interview with Sam Pearsall, Director of Science and Roanoke River Project Director, The Nature Conservancy, May 1, 2008.
93. *See* Elise R. Irwin & Mary C. Freeman, *Proposal for Adaptive Management to Conserve Biotic Integrity in a Regulated Segment of the Tallapoosa River, Alabama, USA*, 16 Conservation Biology 1220 (2002).
94. Swiger, *supra* note 35.
95. Letter from Rodney R. McInnis, Regional Administrator, NOAA Fisheries, to Magalie R. Salas, Secretary, Federal Energy Regulatory Commission, Nov. 29, 2006.

how the risks and costs of regulatory uncertainty vary with context. Here, where the agency mistrusted the good will of the licensee, it was the agency, not the licensee, that was unwilling to brook the regulatory uncertainty of an adaptive approach.

B. *Choice of Active or Passive Management Measures*

Much of the literature on adaptive management focuses on whether adaptive management systems are active or passive—that is, whether the system is designed to test scientific hypotheses. While the distinction is potentially important for all the parameters of the system, it is of most significance in the choice of the initial management measures. In most cases, the initial management measures will be a product of many nonscientific considerations. They may be a product of multiparty negotiations and compromises; the best judgment of regulators and managers in FERC and state and federal natural resource and environmental agencies; or of FERC's attempt to balance environmental considerations against economic considerations and other factors that it is statutorily required to consider.

1. Pros and Cons of Active and Passive Adaptive Approaches

In applying the categorization of risks from scientific and regulatory uncertainty, one should be careful not to confuse the question of active versus passive with the question of how adaptive or flexible a system is. Both an active and a passive system can be highly flexible and changeable with regard to future management measures. Whether or not the system is active (is testing scientific hypotheses through management measures) is a separate question. However, it, too, has effects on the distribution of risks.

Active adaptive management is the best way to eventually reduce scientific uncertainty, in the sense that it rigorously tests scientific hypotheses. It is quite possible that a program of passive adaptive management, while it preserves flexibility and an ability to respond to new information, will never actually yield any additional scientific knowledge about the regulated system. Passive adaptive management could, in fact, result in wasted or inconclusive monitoring efforts, since a monitoring system designed without specific scientific hypotheses in mind may be unsuitable for answering questions that arise later.

However, there is no guarantee that an active adaptive management program will answer the questions it poses in a convenient time frame for making management decisions. Testing a scientific hypothesis can require gathering time-series data spanning years or decades. An environmental advocate who has participated in several relicensings noted that detecting a statistically significant correlation between an animal population and river flows could require collecting data for the entire term of a hydropower license, due to the high variability and stochasticity of river systems. Rather than leave regulatory requirements undecided pending the results of adaptive management, a regulator or environmental stakeholder might prefer the certainty of fixed, front-loaded license requirements. As this participant in relicensings noted: "Do you want to wait that long to make a change? Don't kid yourself that you're going to find out [the answer to scientific questions] in five years . . . you might want to just take your best crack at it and live with it."[96]

In the time scales in which regulators actually act, active adaptive management may not offer any advantage to decisionmaking that cannot be achieved through passive adaptive management. In either case, preserving flexibility in shorter time scales can give regulators the opportunity to change the requirements if something goes wrong. For example, if a fish population nosedives five years after the license is issued, then the regulators might want to have flexibility to order more flows during certain parts of the year. This may not be the result of having tested a scientific hypothesis, but it nevertheless ameliorates the risk of setting the initial flow requirements too low due to the scientific uncertainty that existed at the time of relicensing. Although passive adaptive management is sometimes derided as mere "trial and error," there is a real value in preserving the opportunity and flexibility to try something different when, in the best judgment of experts, the current course of action is not working or new information is obtained. For example, some successful innovations in fish passage in the Columbia River Basin have been the result of trial and error. In one instance, managers discovered that an ice and trash sluiceway was an effective fish passageway.[97]

Furthermore, regulators seeking to follow the active adaptive management path may encounter significant additional barriers in comparison to passive adaptive management. The management measures that would successfully test a hypothesis may not be the same as those that would be most effective in protecting natural resources, in the best judgment of agency scientists. For example, an adaptive management approach to determine the relationship between flows and salmon survival might run counter to efforts to rebuild declining salmon populations.[98] This is illustrated in the case discussed later of the hydropower project on the Lower Bridge River in British Columbia. There, stakeholders ruled out an adaptive management experiment that varied release levels because the proposed experiment to test the relationship between flows and salmon biomass would preclude simultaneous introduction of habitat restoration measures that might introduce a confounding variable into the experiment.[99] Such strictures of rigorous experiment could also run counter to an agency's legal mandates, such as endangered species protections. The necessary experiments might also induce economic costs for other stakeholders who would

96. Interview with Dave Steindorf, American Whitewater, California Stewardship Director, American Whitewater, Apr. 30, 2008.
97. Volkman, *supra* note 16, at 755.
98. *See* Volkman & McConnaha, *supra* note 63, at 1256-57.
99. Lee Failing et al., *Using Expert Judgment and Stakeholder Values to Evaluate Adaptive Management Options,* 9 Ecology & Soc'y 13 (2004), *available at* http://www.ecologyandsociety.org/vol9/iss1/art13/.

see little benefit in testing hypotheses about salmon, but are more concerned about costs, such as electricity rates.[100]

Regulators also would likely confront uncertainty about whether experimentation they envision today will be politically and economically feasible in later years. The Bureau of Reclamation's Glen Canyon Dam's adaptive management program has performed some experiments, including a controlled flood in 1996 to simulate pre-dam spring releases that nourish downstream beaches with sediment; and a 2000 experiment in limiting summer flows to help native fish species. However, other experiments have been hampered by a lack of stakeholder consensus and by economic constraints, such as heightened electricity demand during the 2001 western energy crisis.[101] Similarly, on the Columbia River, despite the devotion of considerable resources to ecosystem restoration research and adaptive management, economic and other human factors have limited the ability to use large-scale experimentation.[102]

The licensee may be relatively indifferent to the question of whether the license terms are being set to test a scientific hypothesis or not; it will mainly be concerned about predicting future costs. It will likely be more concerned with how flexible and changeable the license terms are, which, as noted earlier, is a separate question from whether the system is active or passive.

Active adaptive management would likely be more effective, at least in theory, in eventually reducing scientific uncertainty, since it would have a more rigorous design for answering specific scientific questions. It reduces the risks of designing an ineffective or inadequately funded monitoring program. It increases certain other kinds of risks, such as the risks associated with conducting experiments that might actually harm the resources to be protected.

The following table summarizes how the active/passive design choice tends to affect the distribution (or at least the perception) of risks:

	Risks of Passive or Active Approach Due to <u>Scientific Uncertainty</u>	Risks of Passive or Active Approach Due to <u>Regulatory Uncertainty</u>
Design Is Active/ Hypothesis-Driven	RISK ↓ • Regulators, environmental stakeholders • Failure to learn • Monitoring wrong variables or monitoring ineffectively	RISK ↑ • Regulators: • Future constraints may make continuing experiment difficult • High degree of institutional continuity necessary to implement
	RISK ↑ • Regulators, environmental stakeholders • Choosing measures based on hypothesis testing might not be optimal from standpoint of protecting the resources	RISK ↓ • Licensee: • Future requirements being set arbitrarily or with hidden dam removal agenda
Design Is Passive/Not Hypothesis-Driven ("Trial and Error")	RISK ↑ • Regulators, environmental stakeholders • Failure to learn • Monitoring wrong variables or monitoring ineffectively	RISK ↓ • Regulators: • Future constraints may make continuing experiment difficult • High degree of institutional continuity necessary to implement
	RISK ↓ • Regulators, environmental stakeholders • Choosing measures based on hypothesis testing might not be optimal from standpoint of protecting the resources	RISK ↑ • Licensee: • Future requirements being set arbitrarily or with hidden dam removal agenda

100. *See* Volkman & McConnaha, *supra* note 63.
101. National Research Council, Adaptive Management for Water Resources Project Planning, 80 (2004).
102. Volkman, *supra* note 16, at 760.

2. A Case of Active Adaptive Management—The Lower Roanoke River

As already noted, a party's view of adaptive management is a complex calculation that takes into account both scientific and regulatory uncertainties that can play out in a variety of ways. Although in environmental regulation certainty is often associated with protecting business interests, it is possible at times that a hydropower licensee might be persuaded to favor an active adaptive approach. An active adaptive management system is likely to be defined in more rigorous, clear terms, with less potential for regulators to use it as a means of arbitrarily imposing new requirements later.

For example, on the Lower Roanoke River, The Nature Conservancy (TNC) successfully spearheaded an effort to introduce adaptive management of hydropower dams operated by Dominion Power. Before and during the licensing process, TNC pushed for installation of river gages to collect flood data and developed models relating flow-timing to flood patterns. The modeling data convinced Dominion Power and other stakeholders that an active adaptive management program could empirically adjust peak flow-timing in ways that would produce new data about the underlying causal relationships. That data, in turn, could be used to refine the model over time. Applying the improved model would, in turn, lead to successive refinements in flow-timing patterns, which scientists believed would, in time, produce significant environmental benefits for bottomland hardwood forests and water quality, as well as economic benefits for many property-owning stakeholders affected by flooding. The models also indicated that costs of implementing this adaptive approach would not be inordinately high for Dominion Power.[103]

TNC's heavy investment in data-gathering and modeling during the licensing process reduced initial scientific uncertainty regarding whether their management proposals would be too costly or ineffective. The fact that their approach appeared to be scientifically rigorous helped persuade the licensee to accept some regulatory uncertainty about future costs. TNC's investment in model-building and research also helped build trust, persuading Dominion Power that TNC's talk of adaptive management to protect bottomland forests was not really a mask for a hidden agenda—licensees not infrequently suspect environmental groups of pursuing costly restrictions on dam operations during relicensing in pursuit of an unstated agenda of forcing dam removal.[104]

According to the TNC project manager, the investment in scientific research helped change the currency of the debate from political power and money to information. He noted that in the absence of real information, the debate was "framed by who could swing the biggest financial and political stick."[105] Scientific uncertainty limited the extent to which debate could be driven by science. For example, Dominion Power could argue that flow variations due to peaking power generation had no effect on sensitive resources. Environmentalists might disagree, but without proof, the scientific discussion was stalemated and such questions would be determined by bargaining power rather than science. But once TNC brought scientific data to the table backing its position, and other powerful stakeholders such as federal land management agencies took notice, the issue had to be addressed, at least in part, on the scientific merits.[106]

3. Evaluating Costs and Benefits of Active Adaptive Management: A British Columbia Example

The reduction of scientific uncertainty is a very abstract goal, and decisionmakers may have difficulty deciding whether such an abstract goal warrants the costs and difficulty of implementing an active adaptive management program. When deciding between a passive or adaptive approach, they will likely prefer to evaluate costs and benefits in terms of dollar costs and environmental outcomes. As the authors of an important case study of an adaptive management proposal for a hydropower project in British Columbia observed:

> The value of information must be reported as improvements in expected future performance . . . not in terms of greater knowledge or reduced uncertainty, but in terms of the "expected" value of more fundamental indicators of performance—usually ecological gains, financial costs and, in some cases, others such as recreational use, wildlife habitat, or aesthetics. . . . The knowledge and comfort gained by scientists is useful only if it can be reasonably expected to translate into tangible improvements in the endpoints that people care about . . . .[107]

In other words, it will be necessary to make difficult predictions, not only about how the natural system will respond to different possible management measures, but also how likely it is that scientific experimentation will yield new information, and how much actual environmental benefit such new information will yield. And it will require considering the various costs of conducting this experiment.

The authors of the British Columbia study were addressing a situation in which stakeholders needed to decide between a passive and active approach to managing flow levels from a dam on the Lower Bridge River in British Columbia. A proposed active adaptive management experiment would have tested hypotheses to clarify the causal relationship between release volumes and salmonid recruitment[108] downstream.

103. Interview with Sam Pearsall, Director of Science and Roanoke River Project Director, The Nature Conservancy, May 1, 2008; *see also* Susan L. Manring & Sam Pearsall, *Creating an Adaptive Ecosystem Management Network Among Stakeholders of the Lower Roanoke River, North Carolina*, *USA,* 10 Ecology & Soc'y 16 (2004); Sam H. Pearsall et al., *Adaptive Management of Flows in the Lower Roanoke River, North Carolina, USA*, 35 Envtl. Mgmt. 353-76 (2005).
104. *See* Manring & Pearsall, *supra* note 103, at 11.
105. Interview with Sam Pearsall, *supra* note 103.
106. Interview with Sam Pearsall, *supra* note 103.
107. Lee Failing et al., *Using Expert Judgment and Stakeholder Values to Evaluate Adaptive Management Options*, 9 Ecology & Soc'y 13 (2004), *available at* http://www.ecologyandsociety.org/vol9/iss1/art13/.
108. While there is no standard definition of recruitment, a general definition is that it is "the conversion of eggs . . . to the fish that reproduce in the next generation." Ransom A. Myers, *Recruitment: Understanding Density-Dependence*

Standard models could only explain about 50% of the variation in fish density at base-flow levels, so there was little confidence that the existing habitat simulation models could predict population response to different flow levels.

The stakeholder management group wished to evaluate a proposed adaptive management program that would vary flows above and below this level to gain knowledge about the causal relationship between flows and stock recruitment. The experiment would evaluate four flow levels of 0 cubic meters per second (cms), 3 cms, 6 cms, and 9 cms. The alternative to an active adaptive approach would be a nonadaptive approach implementing a negotiated settlement that had been arrived at after years of litigation, which provided for a water budget of 3 cms for instream flow releases.[109]

The authors of the study engaged in a process to develop expert best-judgment evaluations of the expected costs and benefits of the adaptive approach. Their evaluations helped to reveal that the adaptive approach offered expected environmental benefits and would actually cost less, financially speaking, than the negotiated settlement. However, this exercise also revealed how the rigors of active adaptive management imposed unacceptable opportunity costs in terms of foreclosing other environmental restoration options, and did not have much to recommend it over a conservative nonadaptive approach.[110]

In order to provide decisionmakers with this cost and benefit information, two biologists with expertise on this ecosystem were asked to provide conditional probabilistic estimates of biomass production at the different flow levels. They were also asked to quantify their expectations as to what the experiments would say about the nature of the underlying causal relationship, and the likelihood that the experiments reliably revealed the true state of nature. These values, in turn, yielded estimates of the expected benefits of the experimental and fixed-flow alternatives.[111]

This rough, back-of-the-envelope modeling predicted that the experimental option would somewhat increase the likelihood of good fish productivity outcomes and reduce the downside risk of poor fish outcomes. Interestingly, the experimental option was also predicted to be less costly than the negotiated settlement approach, because it would allow sometimes releasing flows less than the negotiated amount of 3cms.[112]

The adaptive approach was assessed to be less costly than might be expected in terms of lost power production because it would require experimenting with both high and low flows. Money could be saved for the initial years of the experiment without unduly compromising experimental outcomes by designing the experiment in a way that deferred experimentation with high flow-levels and starting the experiment at the lower levels.[113] However, decisionmakers also found that the value of the additional knowledge, in terms of finding the optimal flow-level, was not worth the costs of experimentation, given that existing models predicted good biological results at a flow rate of only 1 cms.[114] The cost that weighed most heavily was an opportunity cost. Because habitat restoration would introduce a confounding variable into the experiment, it was likely that desired habitat restoration projects would have to be foregone during the period of the experiment, even though experts thought such restoration would likely be beneficial.[115]

C. *Monitoring Program Design*

Monitoring programs are now a ubiquitous feature of hydropower relicensing, and the need to monitor appears to be uncontroversial. Monitoring costs are often specified at the outset, providing certainty about costs for the licensee. With active adaptive management, the monitoring program must be specified in considerable detail for a span of many years if it is to produce the sort of data that will answer the scientific questions posed. It is possible to increase regulatory certainty by being highly specific at the outset about the scope and nature of the monitoring program. Initial scientific uncertainty, however, will increase the likelihood that mistakes are made, such as providing inadequate funding or monitoring the wrong variables.

In hydropower licensing, the licensee can be made to pay for monitoring, providing a stable funding source. However, with a more passive, trial-and-error approach, it is more difficult to ensure that such funding is used efficiently. If the monitoring program is clearly specified in advance, but the effort is not guided by clearly defined scientific hypothesis testing, then it will be difficult to know what variables will be useful to monitor, or what protocols to follow, such as sampling rates, sample sizes, and so forth. Monitoring is only likely to answer those scientific questions that drive the development of sampling methods and protocols, and not causal questions posed after the fact. This is a limitation on both active and passive systems. An active adaptive management monitoring system is more likely to be able to provide useful information because it is guided by specific scientific questions. However, it will also be constrained in that it will be set up to answer the particular questions posed during the system design, but may not be able to answer new questions that could arise later.

These limitations on the flexibility of a monitoring system were illustrated in California with the relicensing of the Rock Creek and Cresta projects on the Feather River. An adaptive management program imposed monitoring requirements to evaluate the effects of whitewater flow releases on macroinvertebrates. However, the sampling methodology was only suitable for determining the effect of individual releases, not cumulative effects over longer periods of time, making the results indeterminate when stakeholders raised that question later. Similarly, monitoring efforts unexpectedly discovered

in Fish Populations, *in* Paul J.B. Hart & John D. Reynolds, Handbook of Fish Biology and Fisheries (2002).

109. Failing et al., *supra* note 107, at 3.

110. Failing et al., *supra* note 107, at 3.

111. Failing et al., *supra* note 107, at 7-8.

112. Failing et al., *supra* note 107, at 10.

113. Failing et al., *supra* note 107, at 11.

114. Failing et al., *supra* note 107, at 11.

115. Failing et al., *supra* note 107, at 5.

the presence of the Foothill yellow-legged frog, but because the monitoring protocols had not been designed to measure changes in that particular species' population, managers were unable to determine whether a drop in the annual frog egg mass that they detected represented a significant decline in that species' population.[116]

On the Snake River and the Columbia River, there has been considerable uncertainty over the effect of flow augmentation on salmon populations. A program began in the early 1990s of tagging fish with computer chips in order to track survival by life-stage and correlate that with flows. However, the tagging program was unable to answer fundamental questions about the role played by other variables such as habitat, ocean conditions, and hatchery fish.[117]

The degree of scientific uncertainty at the outset determines how difficult it will be to design an adequate and adequately funded monitoring program. Thus, to the extent possible, adaptive management will benefit from up-front investigation and research into the natural system in order to reduce these scientific uncertainties as much as possible before setting up the monitoring system. This will also help inform decisions about what monitoring is supposed to detect and which variables should be monitored and in which way. These early decisions cannot easily be changed later on. For example, detecting changes in animal population size requires a lengthy time-series of data points before any statistical inferences can be drawn. There are also limits on the ability to adjust monitoring protocols—the procedures for determining where and how samples are taken or measurements made, how often, and how intensively over time and space. If these are changed, it can render older data incommensurable with newer data and again block drawing any meaningful statistical inferences.

D. *Feedback Rules*

Feedback rules govern how information derived from monitoring will be evaluated and how it will feed into revisions of the mitigation and management measures. There are risks and trade offs involved both for highly specific and vaguer feedback rules.

1. Vague Feedback Rules Create Regulatory Uncertainty

Some forms of adaptive management are so vague that they are likely to be ineffective, or to create a great deal of regulatory uncertainty. The license issued in 2003 for the St. Lawrence-FDR Power Project in New York illustrates both. The vague §401 adaptive provisions reserve to the state "the right to modify, suspend, or revoke this certificate when . . . New material information is discovered; Environmental conditions, relevant technology, or applicable law or regulation have materially changed since the certificate was issued."[118] To the extent the state might exercise this authority, it creates regulatory uncertainty about what would be the result. The settlement agreement also creates an additional consensus-based decision mechanism that is so vague it is likely to be ineffective. It provides that the signatories will review the agreement every 10 years to discuss issues not anticipated at the time of relicensing, including environmental and economic conditions. The provision makes no mention of what the potential result of such discussions might be.[119] Nor is it clear how decisions would be made—it appears consensus would be required, giving the licensee an effective veto power.

The license also requires new eel fish passage facilities, and the licensee is required to consult with the FWS regarding development of a plan for studies to monitor their effectiveness. If the upstream American eel ladder is not meeting the established passage criteria, the licensee must make "reasonable efforts" to achieve these criteria through modification of the facilities and/or their operations.[120] The Secretary of Commerce reserves authority to prescribe further fishways during the license term pursuant to FPA §18.[121] This open-ended reservation of authority leaves considerable regulatory uncertainty, since fishways can be quite costly.

2. Specific Feedback Rules Reduce Regulatory Uncertainty but May Be Infected by Scientific Uncertainty

Adding specificity to the feedback rules reduces regulatory uncertainty. However, to the extent they limit future freedom of action, such specificity builds risks into the system arising from the initial scientific uncertainty.

For example, California has imposed specific feedback requirements through CWA §401. California's §401 certifications are handled by the State Water Resources Control Board (SWRCB). The SWRCB has been concerned about uncertainty in areas such as the effects of flows (timing, volume, and water temperature) on fish populations, and the efficacy of fish passage.[122] In some recent relicensings, they are therefore requiring licensees to regularly report and consult with state officials regarding the results of monitoring, imposing clear pathways for state regulators to modify the licenses, and setting up, in some cases, specific requirements to iteratively modify the license terms over time.

One example of this is the Fall River Project, relicensed in 2003, a license under which Pacific Gas & Electric Company operates a diversion dam in northern California. Resources potentially affected by the project include bald eagles and endangered Shasta crayfish, waterfowl, recreational fisher-

116. Interview with Dave Steindorf, American Whitewater, California Stewardship Director, American Whitewater, Apr. 30, 2008.

117. *See* Volkman, *supra* note 16.

118. FERC, Order Approving Settlement Agreements, Dismissing Complaint, and Issuing New License, 105 FERC 61102, 105 (Oct 23, 2003).

119. *Id.*

120. *Id.*

121. *Id.*

122. Interview with Russ Kanz, California State Water Resources Control Board, Division of Water Rights, Mar. 19, 2008.

ies, whitewater boating, and a 6,000-acre wetland/grassland complex known as McArthur Swamp.

The §401 certification requires that after five years, the licensee must report to the SWRCB summarizing the past five years of water quality monitoring, and meet with a representative of the board to determine if beneficial uses identified in the Basin Plan are being protected. The Chief of the Division of Water Rights may then order an additional increment of 50 cubic feet per second (cfs) of flows if beneficial uses are not being sufficiently protected. This process then repeats on a three-year cycle, each time allowing additional flows to be required in 50 cfs increments. This continues until sideboards are reached that place an upper limit on the flows that can be ordered during specified periods.[123]

A question raised by this approach is: how do we know that 50 cfs is enough? Presumably, the requirements are based on SWRCB's initial understanding of the system and an estimate of how much additional flow might be effective in correcting mistakes made in setting the initial operating conditions. However, to the extent there is scientific uncertainty, those estimates may be wrong.

The Lower Roanoke project provides another example of tightly defined feedback mechanisms that provide a good deal of predictability and are clear enough to be readily enforced. However, these feedback rules enjoy an additional advantage—TNC expended over $1 million on monitoring, research, and model-building to understand the system before the adaptive management rules were designed. TNC's willingness to expend such resources stemmed from its ownership of bottomland riparian and hardwood forests that were being damaged by floods. State regulators were curtailing dam releases to hold water in the floodplain in order to protect water quality in the river channel, but this extended inundation, in turn, harmed riparian wetlands and forest.[124]

The adaptive management strategy developed by TNC will adjust within-week peaking flow allocations iteratively at the end of a succession of five-year monitoring cycles. The adjustments will seek to systematically arrive at a point where impact on growing-season inundation has been reduced to insignificance. A variety of different variables can be altered to reduce impacts, including peaking days per week, number of consecutive days of peaking, or the difference between peaking and nonpeaking mean flows. Monitoring data will be combined into an index of deviation quantifying the difference between the river as impacted by the dam and the river in its natural state. Dominion Power will have discretion as to how to change the variables, as long as in each cycle it reduces the deviation by a specified amount relative to the value of the previous cycle's deviation. TNC predicts that this will produce a "preferred solution" long before the end of the 40-year license.[125]

Another approach to initial uncertainty is to establish feedback rules that, while clear, leave considerable freedom of action in the hands of the regulators. An example of this is the license for the Pelton Round Butte Hydroelectric Project in Oregon. This project consists of three dams operated by Portland General Electric and the Confederated Tribes of Warm Springs on the Deschutes River.[126] Threatened bull trout and steelhead are present below the impoundments, and bull trout are present within the impoundments.[127] The project impoundments have caused impacts that violate state water quality standards for water temperature, dissolved oxygen, and pH.[128]

As a §401 certification condition, the Oregon Department of Environmental Quality (ODEQ) required construction of a selective water withdrawal (SWW) facility. The SWW facility is expected to help improve water quality below the dam, as well as to facilitate the capture of emigrating smolts from the impoundment in support of a program to reintroduce salmon and steelhead above the Round Butte Dam.[129] The ODEQ reserves the right to request, up to twice a year, that the applicants modify the percentage blend of surface and deep water discharged from the SWW facility. For the first five years, the modifications must fall within a range set forth in an implementation agreement and must not involve any additional capital expenditures; after five years, these constraints are removed.[130] The Pelton Round Butte license illustrates how §401 provides state regulators an ongoing role and ability to modify the license requirements over time in response to new information. This introduces some regulatory uncertainty for the licensee, especially since there are no strict sidebars on the scope of changes after five years. However, future modifications will not be completely new or unexpected, in that they would be based upon adaptive management pathways conceived at the time of condition writing. Certain parameters (here flow mixing) will be variable, while other variables, such as dam removal, are not contemplated as an adaptive management response.

E. *Oversight and Decisionmaking Authorities*

There are two main issues with respect to the design of oversight and decisionmaking authorities. One is ensuring institutional continuity. The other is establishing how an authority will make decisions.

1. Institutional Continuity

Adaptive management will usually require sustained oversight for a period of decades. This could be a problem for regulatory agencies already stretched thin by their responsibilities, and subject to the vagaries of government budgeting. The design of an adaptive management system must take into account the need to ensure that the decisionmaking and

123. *Id.*
124. *See* Manring & Pearsall, *supra* note 103.
125. *See* Pearsall et al., *supra* note 103.
126. CWA §401 Implementation Agreement, Pelton Round Butte Hydroelectric Project, 1.
127. *Id.*
128. *Id.*
129. *Id.*
130. Confederated Tribes of Warm Springs Reservation of Oregon and Portland General Electric Co., Pelton Round Butte Project Water Quality Management and Monitoring Plan, Fourth Draft Proposal, Mar. 2002, 3.

oversight institutions can function effectively and retain continuity and institutional memory over many years. Regulators pressed for resources and stretched thin over many areas of responsibility may have short planning horizons, and well-intentioned adaptive management schemes could founder due to lack of continuous long-term follow-through.[131]

For example, California's SWRCB's regulators have begun using adaptive management in their §401 certifications more often, but still prefer, if possible, to obtain the necessary information to craft definite requirements at the outset, and prefer to avoid using adaptive management as a means of deferring research or hard decisions.[132] The imposition of these requirements on licensees could create new strains on the agency in the future, since it will be actively involved in managing the operations of these licensees for years to come, and these agencies are already hard-pressed to supervise existing post-license monitoring. One attorney active in representing environmental interests in hydropower licensing noted that SWRCB's §401 program became short-staffed and suffered when the state attempted to shift the agency's funding to a user-fee system that got tied up in litigation.[133]

Continuity of funding need not be a problem for the regulators if they require the licensee to provide it. The §401 certification for the Pelton Round Butte Hydroelectric Project in Oregon requires the licensees to provide $25,000 annually for the ODEQ's costs of overseeing the §401 conditions. The fee expires after 10 years, but can be renewed.[134] As already noted, it may be difficult to accurately predict how much monitoring will cost, particularly where there is large scientific uncertainty and/or the program is one of passive adaptive management. A larger initial investment in research and modeling would help make such projections more reliable.

Agencies other than FERC must consider how and whether they will have the ability to enforce adaptive management requirements. The default is that with respect to oversight and enforcement, the FPA makes FERC responsible for enforcing hydropower license terms. FERC's willingness to aggressively protect the environment and natural resources has often been questioned. Other agencies can gain an enforcement role by incorporating it into side agreements that they require licensees to sign when they impose mandatory conditions on the license. For example, the state of Oregon required the licensee to enter such an agreement on the Pelton Round Butte Hydroelectric Project. The agreement includes provisions requiring the licensee to fund the state's oversight of the adaptive management program, and specifies enforcement mechanisms including revocation of the §401 certification, citizen suits, and civil penalties.[135]

A less tractable problem is simply ensuring institutional memory and continuity of effort. One of the foremost proponents of active adaptive management has noted that ambitious adaptive management programs rarely get off the ground and can rarely be sustained without the individual efforts of highly motivated regulatory staff who devote considerable personal resources of time and energy to the project.[136] This is a fragile foundation for the long-term success of a complex regulatory effort that could run for decades. One observer who helped craft a complex licensing settlement on the Feather River, which included adaptive provisions, says that 10 years later, he and a staff member from the utility were the only individuals still involved who worked on drafting the settlement, and he said that even they sometimes had trouble remembering what some of the language in the settlement was supposed to mean.[137]

2. Decisionmaking Structure

Another area that is challenging for adaptive management is determining how decisions will be made in response to new information. Often, licensing settlement agreements create a committee made up of various parties, including regulators, and perhaps representatives of the licensee and stakeholders too, such as environmentalists or tribes. Sometimes these committees cannot make a decision without unanimity.[138] Requiring unanimity gives members of the committee a veto power over the imposition of changes. For example, in the case of the Lower Roanoke River, development of the index of variability that drives the adaptive management feedback mechanism, as well as other decisions, will be supervised by a committee that must operate by consensus. A consensus approach, which gives the licensee a potential veto, enhances regulatory certainty for the licensee but not the regulators. In the event of a disputed decision, the Roanoke River settlement agreement contains provisions requiring binding arbitration.[139]

Where consensus is required and parties with divergent interests hold a veto, adaptive management may simply be equivalent to postponing hard decisions. Especially where the system is a passive rather than active adaptive system, the monitoring program may not yield any rigorous new scientific insights, and future decisions will be just as bound to expert best judgment as they were at the outset, albeit with the benefit of some additional data upon which experts can form impressions. Furthermore, the same divisions among interests may make it just as hard to reach agreement as before: "[W]here there is conflict over the social value of action, as has been the case in fisheries, the consensus approach encounters a fundamental limitation: consensus management is vulnerable to value differences clothed as scientific dispute. Lack of consensus among experts often

131. *See* Walters, *supra* note 12.
132. Interview with Russ Kanz, California State Water Resources Control Board, Division of Water Rights, Mar. 19, 2008.
133. Richard Roos-Collins, remarks at seminar on hydropower law sponsored by California Center for Environmental Law and Policy, U.C. Berkeley School of Law, Sept. 11, 2007.
134. CWA §401 Implementation Agreement, Pelton Round Butte Hydroelectric Project, 5.
135. *Id.*, at 7.
136. *See* Walters, *supra* note 12, at 306.
137. Interview with Dave Steindorf, American Whitewater, California Stewardship Director, American Whitewater, Apr. 30, 2008.
138. Swiger, *supra* note 35.
139. Comprehensive Relicensing Settlement Agreement for the Roanoke Rapids and Gaston Dam Project, FERC Project No. P-2009, June 2003, PL-13.

becomes a bar to action."[140] There is no guarantee that even the regulatory agencies will be able to reach consensus, since they usually have differing missions and constituencies. A study of adaptive management efforts on the Columbia River noted that salmon recovery efforts have been hindered by "the institutional fragmentation in the Columbia River's management regime . . . a number of federal, state, and tribal management and regulatory agencies are sometimes doing overlapping work, sometimes cooperating with each other, and sometimes working at cross-purposes."[141]

The Lower Roanoke River example discussed earlier provides another example of such mission fragmentation. Originally, TNC hoped it could persuade state water quality regulators to impose its adaptive management plan through the §401 process. But the state regulators' initial emphasis was on traditional measures of in-channel water quality, such as dissolved oxygen levels, which they felt could be impaired by the plan. They were less receptive than federal land managers to the idea of adaptive management to improve forest health in the floodplain. Eventually, TNC shifted its focus toward achieving its adaptive management goals by building a consensus for adaptive management among stakeholders and federal agencies through long negotiations, combined with its own investment in research, monitoring, and modeling. Meanwhile, bureaucratic snafus caused the state to accidentally waive its §401 authority.[142]

TNC concluded from the Roanoke River example that adaptive management of a complex system could not be effectively implemented via the top-down fiat of a particular agency, but rather required broad consensus: "Regulatory authorities are characteristically fragmented and noncomplementary, and together do not constitute the necessary and sufficient set of authorities to produce unified, comprehensive results."[143]

V. Conclusions: The Promise of Adaptive Hydropower Regulation

A. *The Need for Adaptive Management to Improve Environmental Outcomes*

Conventional hydropower licenses are designed to prospectively lock in dam operating requirements and mitigation measures for decades. These conditions are designed primarily by FERC, an agency whose mandate makes the environment just one of many factors to balance, and that has a tradition of deferring to hydropower interests.

Given the considerable scientific uncertainty about how to best balance hydropower production and other goals with environmental protection, there are only two alternatives to this conventional mode of doing business that can be assured of producing better environmental outcomes. One would be to force FERC to put a greater stress on environmental protection, and to routinely adopt more risk-averse environmental protection measures, with less regard for cost (perhaps up to and including dam removal). The second alternative would be to make hydropower licenses adaptive—to deal with scientific uncertainty through learning and iterative adjustment.

Federal natural resource agencies and state water quality agencies have the legal authority to push either of these approaches. Taking the environmentally risk-averse approach of front-loading licenses with strict environmental conditions has obvious appeal in terms of environmental goals, but could be economically wasteful to the extent it promotes more costly measures than are actually needed. It could also have the undesired side effect of unduly limiting the production of clean, carbon emissions-free hydropower. Furthermore, it provides no mechanism for learning or adapting to new circumstances. Thus, there is a strong case for incorporating adaptive management into more, perhaps all, hydropower licenses.

Licensees and FERC will likely resist adaptive provisions if they seem too open-ended. The resource protection agencies have the legal authority to insist, but the political dynamics of settlement negotiations could in some cases prevent them from doing so. There are generally not policy prescriptions that can dramatically alter those dynamics. However, as illustrated in the Roanoke River example, an investment in front-end science and modeling can have an effect in reframing such a debate in terms of science rather than in terms of raw political power. Thus, a well-thought-out program of investing in preparatory research on high-priority projects not only paves the way for successful implementation of adaptive management, but also can help address political obstacles.

B. *The Need to Prioritize and Invest in Early Research and Modeling*

Active adaptive management requires such investments in front-end research, surveys of important resources such as plant and animal populations, and studies and modeling of hydrology and other processes. This work needs to be done early in order to frame hypotheses and establish the goals of experimentation in a rigorous fashion. Passive adaptive management also benefits from such up-front research, because the design of monitoring programs and feedback mechanisms necessarily incorporates causal assumptions about the dynamics of the ecological system, assumptions that are infected by whatever data gaps or scientific uncertainty exists when the adaptive management program is designed.

However, the resources probably are not available to do a good deal of research and modeling for every licensed hydropower project. Therefore, federal and state agencies that deal with multiple projects under their jurisdiction need

140. Kai N. Lee, *Adaptive Management: Learning From the Columbia River Basin Fish and Wildlife Program*, 16 Envtl. L. 431, 450 (1986).
141. National Research Council, *Upstream: Salmon and Society in the Pacific Northwest*, quoted in Volkman, *supra* note 16.
142. Interview with Sam Pearsall, *supra* note 103.
143. Susan L. Manring & Sam Pearsall, *Creating an Adaptive Ecosystem Management Network Among Stakeholders of the Lower Roanoke River, North Carolina, USA*, 10 Ecology & Soc'y 16 (2004).

to establish a system for determining priorities and ranking hydropower projects according to the need for, and promise of, such research-based adaptive management. As just mentioned, one reason to set a high priority on gathering data and doing modeling at the outset is that it may help to reframe the terms of negotiations that have become bogged down by disputes that are to any extent empirical questions.

Another obvious starting point for setting priorities is the presence of sensitive resources, such as valuable fisheries or endangered species. The next question is whether the parameters of dam operation are such as could be meaningfully varied to help those resources, and at what cost. Varying release schedules from a reservoir is much cheaper than building new physical fish passageways or removing a dam. The analysis also requires identifying the key scientific uncertainties and what sorts of research or monitoring would be needed to address them. Where there is a promise of particularly effective adaptive management, agencies and other stakeholders should invest in beginning such research before formal relicensing proceedings begin.

C. Active or Passive? Or Both?

It is likely not feasible to incorporate active, hypothesis-driven adaptive management into many licenses. On many rivers, external constraints, such as the need for electricity or flood control, may limit experimentation, not to mention the need to protect endangered species that could be harmed by experimentation of this sort. Such authority need not be unbounded, however. Carefully considered boundaries or sideboards can play a useful role in reducing regulatory uncertainty and facilitating decisions about funding, monitoring needs, and institutional design, as illustrated in the Pelton Round Butte license discussed earlier. Nevertheless, when it comes to hydropower licensing, even weaker, passive forms of adaptive management (sometimes called trial and error) may well be an improvement over the status quo approach.

In fact, some passive adaptiveness should be a component of every license, even those that also implement adaptive management hypothesis-testing. Hypothesis-testing on the active model may take decades, and cannot possibly address all the contingencies that could arise. The real-world exigencies of managing dams under changing environmental conditions and uncertainty require the reservation of a general authority to make ad hoc revisions in response to the unforeseen.

D. Design Considerations to Minimize Risks

How the key parties view an adaptive approach depends on individual circumstances. While conventionally it is hydropower licensees who seek certainty and environmentalists who wish to retain the ability to change license terms over time, this is not always the case. Where regulators are risk-averse and/or willing to exercise their full legal authority to impose strong, costly up-front protections, they may desire certainty more than the regulated parties.

The least desirable outcome is one in which, due to these risks and uncertainties, the parties collaborate to create a vague system that simply fobs off difficult decisions on future generations. A passive adaptive management program that does not clearly specify the feedback linkages could have some benefits, but only if it is coupled with the best possible effort to design adequate protection measures at the front end, leaving the adaptive management program as a safety valve in case that best effort proves insufficient.

Measures exist for assuring some regulatory certainty even where the license incorporates flexibility and changeability. Clear feedback rules and sideboards are two examples. However, these mechanisms also are likely to build into the adaptive system constraints that are founded on incomplete scientific knowledge. Leaving these linkages and decision rules unspecified creates greater freedom of action but more regulatory uncertainty. Again, the larger the initial investment in modeling and research, the better these risks can be controlled.

Another key aspect of an adaptive system is the institutional design for oversight, enforcement, and decisionmaking. Regulators (aside from FERC itself) can reduce their own regulatory uncertainty by requiring licensees to fund the adaptive management programs, and requiring the licensees to enter into implementation agreements that give the regulators authority to enforce the requirements. Institutional continuity is likely to be a pervasive problem. Regulatory agencies may have difficulty maintaining the institutional memory and may be distracted by other duties or funding constraints when it comes to overseeing the implementation of an adaptive management program that was designed years or decades ago. Regulators and stakeholders need to compare and discuss models that have been or might be tried for funding and governance of adaptive management oversight bodies.

Adaptive management is often the product of settlement negotiations. In that context, it is probably inevitable that many adaptive management systems will create a decision-making group consisting of regulators and stakeholders that operates by consensus. It is preferable to create a decision-making structure that cannot be readily paralyzed by a single party veto. If there is no ability to reach consensus on protection measures today, then it will not do to simply state that a future committee of stakeholders will act by consensus. There can be benefits to a committee approach, such as avoiding having decisions being driven by the narrow mandates of a single agency. But rules need to be created for allowing decision in the absence of complete consensus.

Even where there is a high degree of trust and a cooperative spirit prevailing today, this spirit may not persist in 10 or 20 years when none of the same individuals are involved. Consensus can be fragile. Not only may the licensee balk at new requirements, but agencies have varying missions and may not always be in agreement. An adaptive management system should clearly spell out how decisions are to be made, and the mechanisms to be employed for resolving disputes.

Agencies that have the ability to insert mandatory conditions into licenses would be more likely to achieve their goals if they make themselves the sole or overriding decisionmaking authority when it comes to key adaptive management decisions, such as deciding when monitoring results call for a major change in operations or mitigation measures. Ideally, even where decisionmaking is by committee or consensus-driven, agencies should retain a backstop authority to impose a mandatory response where such a system breaks down. An open question is the degree to which agencies will be willing to shoulder that responsibility for implementation.

E. Learning From Our Experience With Adaptive Management

A good deal of agency or licensee apprehension about adaptive management likely arises from unfamiliarity or a general reluctance to innovate. It is certainly the case that the idea of adaptive management of hydropower licenses raises many questions. These questions are likely being addressed in a wide variety of ad hoc ways in many separate licensing proceedings going on around the country. A more systematic effort to learn from these efforts and disseminate successful or promising ideas and approaches could break down the resistance to adaptive management, and allow agencies and licensees to make a more reasoned assessment of whether, on balance, they can benefit from the risk trade offs that adaptiveness brings about.

At present, FERC is not systematically gathering information about adaptive management provisions in the licenses it administers. Negotiations on hundreds of individual licenses will be occurring around the country in coming years. These different proceedings have some common players at FERC and some of the national stakeholder organizations, but in general are fragmented and involve many different state regulators and federal field office personnel all over the country. Not enough is being done to pool what is being learned in these different proceedings about the possibilities for adaptive management. There should be a systematic effort to compile the licenses and settlements that contain adaptive provisions, to analyze the adequacy of the language and terms of these adaptive licenses. The questions are many:

- What sorts of adaptive management approaches are being tried in what situations?
- How are the relevant agreements and §401 certifications being crafted?
- What sorts of institutional arrangements are being tried? Do we have sufficient experience yet to begin evaluating how they are working?
- What are the options that are being tried for structuring feedback linkages and decisionmaking? How can oversight bodies be constituted and funded? What mechanisms might be used for resolving conflicts or dealing with breakdowns in consensus?
- What is the experience so far of state water quality regulators and federal agencies that have demanded adaptive management? Have the programs introduced so far been working as hoped?
- Are agencies finding the programs difficult to supervise? How are they dealing with the problems of institutional continuity?
- What are the attitudes of hydropower licensees to these provisions? Are they finding that they can live with adaptive management, and that they are able to obtain sufficient certainty about their ability to achieve acceptable economic returns on their operations despite the uncertainties created?

We should be doing more to apply the experience being gained to these questions. One could envision a fruitful conference that brought together experts from the many stakeholder and regulatory bodies that participate in hydropower regulation to share the presently fragmented knowledge and experience on these questions.

F. When to Adaptively Manage

The examples discussed here suggest some considerations that could be applied to identifying hydropower relicensings where adaptive management of some form could be most usefully applied. As a starting point, I posited that some adaptiveness should be built into every license. The complex and dynamic nature of all ecosystems and the further changes wrought by climate change make it impossible to set management and mitigation measures for the next 30 to 50 years with a high level of confidence. Over time, we will learn more about the systems, the systems will change, and the management measures need to be able to change, too. Every hydropower license needs to allow for adaptation, and provide monitoring, feedback mechanisms, and institutions capable of enacting such changes.

Nevertheless, the success of adaptive management is much greater where there is a serious investment of resources. There is a need at the outset for scientific research, surveys, studies, and modeling to base the management measures on. There is a need for long-term funding for monitoring and to ensure institutional continuity and oversight. Because adaptive management requires resources, and resources are limited, there will be a need to set priorities among the hundreds of projects due for relicensing. Where will adaptive management be most useful?

The value of the natural resources threatened by the dam, and the value of the power and other economic benefits the dam produces, will lead to certain projects receiving a great deal more political attention, and potentially more resources, than other projects. These factors will be expressed in the priorities of government agencies and their political constituencies, as well as the priorities of advocacy organizations and the corporate priorities of licensees. That such forces will lead to some projects receiving more attention and resources than others is an inevitable fact of life and even in many instances a rational reflection of what is actually important to society.

In such high-priority cases, it may be easier to propose costly adaptive management measures. In such instances as well, adaptiveness might help to resolve disputes. Where negotiations have become difficult because of disagreements that are in large part empirical questions, the adaptive approach may introduce flexibility into negotiating positions by reframing the debate from a dispute over absolutes to a discussion of ranges of possible outcomes and pathways for dealing adaptively to such different outcomes. The willingness of regulators and environmental advocates to embark on an adaptive program could be a middle ground between entrenched positions of business as usual on the one hand or dam decommissioning on the other. Such flexibility might be provided by either passive or active approaches.

A carefully designed active, hypothesis-driven approach may be superior for winning the trust of licensees and convincing them that adaptive management is not just a cover for perpetually shifting or ramping up their license requirements. And the rigor of active adaptive management can assuage fears that an adaptive management program is just a cover for making regulatory requirements vague.

However, active adaptive management is not necessarily the best approach merely because people think the project is a high-value one or the resources at issue are important. Scientific hypothesis-testing cannot be implemented everywhere. The rigors of the experimental design may run up against economic constraints, and can lead to environmental opportunity costs, since the design that yields the best scientific data might foreclose certain environmental protection measures. For example, it might not be feasible to conduct certain experiments with federally listed endangered species whose management is governed by strict legal conservation mandates. It also must be kept in mind that certain hypotheses may take decades to successfully test. Active adaptive management may thus not be the most flexible or the most able to address unexpected developments. Nor is it always the case that the questions that can be answered in a scientifically rigorous way reflect the most important questions or priorities. Active adaptive management should not be implemented unless it can yield results that can influence management decisions within the time frame that such decisions can usefully occur.[144]

Adaptive management, whether active or passive, cannot be implemented without thought to institutional design and continuity. Regulators who require an adaptive approach but do not address the need for long-term continuity in management, oversight, and monitoring, will be setting themselves up for failure. Licensee proposals for adaptive management in place of certain, fixed requirements should be viewed skeptically unless there is a serious commitment to ensuring continuous and effective oversight.

This Article has shown that there are multiple approaches to adaptive management, with their own advantages and disadvantages. Adaptiveness in some form is probably required in virtually every license. However, it is not a panacea and should not be a cover for avoiding difficult decisions. At the same time, however, regulators and stakeholders should not be too rigid in always seeking certainty. A rigid, nonadaptive approach is not necessarily less risky than an adaptive approach; it merely creates different kinds of risks. Embracing the most costly environmental protection measures may foreclose valuable opportunities to learn and improve stewardship. Retaining flexibility, with clearly defined pathways for gathering new information and feeding such information into future decisions, may be the more rational response to scientific uncertainty. Erring on the side of rigid and costly protection measures could unnecessarily reduce the nation's capacity to produce clean, low-emissions energy, and cause a misallocation of limited environmental protection resources. At the same time, licensees who demand too much regulatory certainty may lose out on opportunities to find common ground with their opponents. No one is likely to know at the outset of a licensing negotiation how to optimally manage a given dam in the future, and all sides in these multiparty negotiations can potentially benefit from structuring the license so that learning takes place, mistakes can be corrected, and beneficial trade offs or improvements can be discovered over time.

144. *See* Failing et al., *supra* note 107.