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How Do You Learn from a River? Managing Uncertainty in Species Conservation Policy

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HOW DO YOU LEARN FROM A RIVER? MANAGING UNCERTAINTY IN SPECIES CONSERVATION POLICY

John M. Volkman*

Abstract: As the Puget Sound region embarks on a new chapter in the story of the Endangered Species Act, experiences with fish and wildlife restoration efforts in other locations can be instructive. This Article reviews conservation efforts in the Columbia River Basin, and it explains the major role that scientific uncertainty plays in salmon conservation efforts. This discussion describes the debate between traditional fish and wildlife management, which focuses more on individual populations and mitigation technologies, and recent scientific reports, which urge more reliance on naturally functioning rivers and watersheds. The Article also describes a variety of learning tools that have helped in managing the scientific uncertainty that this debate reflects. These tools stem from an idea called adaptive management, a way of learning from experience. The tools now include initiatives in applied research, collaborative modeling, independent scientific advice, and ecological syntheses that shape policy development. Some of the insights this work has generated, particularly the importance of building conservation programs around natural processes and population structures, offer substantive guidance for other salmon recovery efforts. This Article concludes that furthering collaboration between science and policy will play a major role in the success of species conservation programs, but ecosystem-scale experimentation is a puzzle that still needs a solution.

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* Senior Policy Advisor, National Marine Fisheries Service, Portland, Oregon. When this Article was written, the author was General Counsel of the Northwest Power Planning Council. The views expressed, however, are the author’s, not those of either agency. This Article is dedicated to the late Cary Jacquelin Volkman, from whom the author learned almost everything. I am grateful to Ronda Larson for her insightful editing, and to Kai Lee and John Shurts for their thoughtful comments.

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I. INTRODUCTION

Species conservation in the Pacific Northwest has come to a new crossroads. With the listing of Puget Sound and Willamette River salmon under the Endangered Species Act, cities such as Seattle, Washington, and Portland, Oregon, are sharing habitat with listed species and joining other parts of the Northwest in a complex species conservation debate. These communities are faced with learning a new landscape—not just a new law, but the complex connections between humans and other species in large ecosystems. The lack of recognizable landmarks in this new terrain is likely to be an unwelcome surprise.

In many cases we have years of experience working with these problems,¹ and the Columbia River experience in salmon recovery is

1. Conflict over declining salmon runs is old news in the Puget Sound region. Bruce Brown's book, *Mountain in the Clouds: A Search for the Wild Salmon* (1995), evokes the decline of wild salmon in western Washington and the role of habitat destruction, fish hatcheries, and fisheries management in contributing to the decline. Puget Sound was a primary arena for the Indian treaty fishing conflicts of the 1960s. The struggle led to Judge Boldt's landmark decision in phase one of *United States v. Washington*, 384 F. Supp. 312, 342 (W.D. Wash. 1974), guaranteeing the Puget Sound tribes an equitable opportunity to fish. Phase two of *United States v. Washington*, 506 F. Supp. 187 (W.D. Wash. 1980), was less conclusive and involved claims to environmental protection for salmon. See generally Fay G. Cohen, *Treaties on Trial: The Continuing Controversy over Northwest Indian Fishing Rights* (1986); Felix Cohen's *Handbook of Federal Indian Law* 441 (Rennard Strickland et al. eds., 1982); Charles F. Wilkinson, *Crossing the Next Meridian: Land, Water, and the Future of the West* (1992). Parties to the Puget Sound salmon conflicts have also put together some of the more creative efforts to settle these controversies collaboratively. See Kai N. Lee, *Compass and Gyroscope: Integrating Science and Politics for the Environment* 120-24 (1993) [hereinafter *Compass and Gyroscope*]; Cindy L. Halbert & Kai N. Lee, *The Timber, Fish,*

particularly instructive for its efforts to manage scientific uncertainty in conservation policy. Columbia River salmon have been in decline since the early part of the century. Beginning in the 1960s, the declines spurred major shifts in the way government dealt with salmon issues. The declines have fueled Indian treaty-fishing litigation, threatened the region's energy supply, and spawned a battery of remedial statutes, international treaties, and court settlements. Taken together, the Columbia River remedial programs constitute what two commentators called the "most ambitious and costly effort at biological restoration on the planet."² Yet, in the early 1990s, Columbia River salmon were listed under the Endangered Species Act, and there is "profound uncertainty about the solutions."³ Part of the Columbia River story is that of institutions coming to grips with these uncertainties. The Columbia River effort has involved Indian tribes, states, federal agencies, interest groups, and the Northwest Power Planning Council, an interstate entity.⁴ The effort has generated programs that are complex and well financed. These programs blend planning, negotiation, and litigation. They have a considerable body of law to support them, including the full weight of the Endangered Species Act.⁵ Yet not only are many Columbia River wild salmon headed for extinction, the idea that any instrumentality of government can navigate a sensible course through these problems is increasingly in question. So, while the Columbia River has the jump on the Puget Sound region when it comes to working with the Endangered

and Wildlife Agreement: Implementing Alternative Dispute Resolution in Washington State, 6 Northwest Env'tl. J. 139 (1990).

2. Kai N. Lee & Jody Lawrence, *Adaptive Management: Learning from the Columbia River Basin Fish and Wildlife Program*, 16 Env'tl. L. 431, 433 (1986) (footnote omitted). For background on the remedial legislation and the Indian treaty fishing cases, see Charles F. Wilkinson & Daniel Keith Conner, *The Law of the Pacific Salmon Fishery: Conservation and Allocation of a Transboundary Common Property Resource*, 32 U. Kan. L. Rev. 17, 46-51 (1983), and Michael C. Blumm, *Why Study Pacific Salmon Law?*, 22 Idaho L. Rev. 629 (1986).

3. *American Rivers v. National Marine Fisheries Serv.*, Civ. No. 96-00384-MA, slip op. at 14 (D. Or. Apr. 3, 1997) (quoting William Stelle, Jr., Regional Director of National Marine Fisheries Service).

4. See 16 U.S.C. §§ 839-839h (1994). See generally Michael C. Blumm, *The Northwest's Hydroelectric Heritage: Prologue to the Pacific Northwest Electric Power Planning and Conservation Act*, 58 Wash. L. Rev. 175 (1983); Roy Hemmingway, *The Northwest Power Planning Council: Its Origins and Future Role*, 13 Env'tl. L. 673 (1983); Kai N. Lee, *The Path Along the Ridge: Regional Planning in the Face of Uncertainty*, 58 Wash. L. Rev. 317 (1983).

5. See John M. Volkman, *The Endangered Species Act and the Ecosystem of Columbia River Salmon*, 4 Hastings West-Northwest J. Env'tl. L. & Pol'y 51 (1997).

Species Act, the Columbia has an equally dark theme—vanishing wild salmon species.⁶

This lack of success in halting species declines begs scientific attention. Why, with these significant conservation efforts, are wild species still declining? Are we aiming at the wrong problems? Are we linking effects with the wrong causes? Are remedial efforts, no matter how intensive, simply unable to keep pace with human development? To what extent are species declines related to climatic or oceanic changes over which regions like the Northwest have little control? If we do not yet have the answers to these questions, how can we begin to find them?

This Article analyzes the Columbia River experience in building collaborative relationships among policy makers and scientists to address these uncertainties. Part II surveys uncertainties in species conservation policy, historic approaches to fish and wildlife management, and the effect of the Endangered Species Act on the Columbia River debate. Part II also describes two landmark reports on the conservation of Pacific salmon and how these reports have pushed the Columbia River effort to a broader ecological plane. Part III explains an initiative called adaptive management—a way of collaboratively managing uncertainty in conservation policy—and the Columbia River parties' experience in implementing it. Part IV concludes that this type of collaboration is not just a compelling idea, but that only a productive, long-term interplay between science and policy can spell success in species conservation.

6. The experience of vanishing species is not unique to the Columbia River and Puget Sound. In 1988, the U.S. General Accounting Office (GAO) reported that only five of 650 species listed under the Endangered Species Act had recovered with about the same number of extinctions. See U.S. Gen. Accounting Office, *Endangered Species Act: Management Improvements Could Enhance Recovery Program* 18 (1988). Moreover, some of the "recoveries" were due to the discovery of additional animals rather than to recovery efforts. For the bulk of listed species, the Act apparently succeeded only in stabilizing a downward trend. See Timothy H. Tear et al., *Status and Prospects for Success of the Endangered Species Act: A Look at Recovery Plans*, 262 *Science* 976, 977 (1993) (reporting that recovery plans generally aim for lesser objective than regulatory definition of recovery); Fish & Wildlife Serv., U.S. Dep't of the Interior, *Report to Congress: Endangered and Threatened Species Recovery Program* 3 (1990) (observing that while "there can be successes in recovery, removal from the list is not a reasonable goal for all endangered species"). If the objective is long-term species recovery and conservation, federal agencies administering the Endangered Species Act are also feeling their way toward a complex solution that will involve far more than the Endangered Species Act.

II. BACKGROUND

The science of ecology attempts to bring scientific knowledge and methods to bear on complex problems that transcend the bounds of traditional scientific disciplines. While ecological science is an invaluable tool in managing these problems, it cannot produce precise answers to many questions in species conservation policy, and the result is large areas of uncertainty. But uncertainty does not have to lead to helplessness if it is guided by a coherent, albeit general, understanding of the relevant ecological landscape. Recent scientific reports portray the need for more naturally functioning watersheds rather than the fragmented mitigation programs that have characterized fish and wildlife management up to this point.

A. *Uncertainty*

Even people aware of the problem of shrinking biodiversity are likely to be surprised by how much scientific uncertainty there is in species conservation policy. Ecological science, the science that studies the connection between plants, animals, land, water, light, and other factors—all of the things that make up ecosystems—is indispensable to species conservation policy because it attempts to integrate scientific knowledge across species and landscapes. However, it is a much less exact thing than the word “science” sometimes implies. Although ecosystem science has substantial capabilities, it is a far cry from Newtonian physics, and is perhaps closer to atmospheric science or economics, which also deal with complex integrated systems. All “are sciences of immense practical importance, and . . . show their value primarily through broad-brush analysis, illustration of mechanisms, and short-term predictions.”⁷

Ecology’s lack of resolution is characteristic of our knowledge of salmon and salmon ecosystems. We do not understand salmon very well. In many cases we do not know what role ecological factors play in their migration, and we cannot pin down the precise ecological mechanisms that have evidently been pushed out of kilter by development. Moreover, the unusually large migratory range of the species amplifies the scale of our uncertainty. A salmon that migrates from the interior mountains of

7. William M. Lewis, Jr., *The Ecological Sciences and the Public Domain*, 65 U. Colo. L. Rev. 279, 290 (1994).

Idaho, down the Snake and Columbia Rivers to the Pacific Ocean, north to Alaska, and back to its natal stream encounters an enormous collection of influences, some of them quite obscure. Salmon spend most of their lives in the ocean, where conditions change from year to year and decade to decade. Because of the ocean's enormous size and complexity, and because these changes in ocean conditions occur over such long time periods, the ocean is something about which we know very little and the problem of evaluating cause and effect is especially complex. Each of these influences individually may affect salmon, and all of them together—from the headwaters to the ocean—can have an immense influence. But it is difficult to tie a particular effect (such as salmon survival) to a particular cause (such as a mitigation effort) when these influences are so diverse and undifferentiated.

While this Article is concerned with uncertainty, a caveat is warranted. It is true that there are many things affecting species conservation about which we know too little, and in some respects our ignorance is remarkably deep. However, ecosystems are not just teeming masses of incalculability. Things are known, and in some ways the uncertainty in this area is no greater than the uncertainty that pervades other parts of life. If certainty as to consequences were required, the nation would never have agreed to such an open-ended document as the Constitution, the White House would still be mulling over the purchase of the Louisiana Territory, and Congress would be waiting for more detailed hydrographic maps before opening the West to settlement. Almost all aspects of human endeavor, certainly economics, defense, and social policy, involve big unknowns in a world that will not wait for certainty. In many instances, we proceed in the face of uncertainty with the assumption that we know well enough what we are doing and can learn more as we go along. This Article, then, is a divided counsel: uncertainty is real, it is inescapable, and it should be planned for, but it should not be used as an excuse for avoiding decisions.⁸

8. The National Research Council has made the point in relation to Pacific salmon:

[There is a] great deal of knowledge that has been obtained about salmon—clearly enough to substantially improve their prospects for survival if applied wisely. Such information should be used to the fullest extent possible in implementation of projects, watershed planning, and other programs designed to assist the survival and sustainability of salmon. To simply wait for new research, new ideas, and new technology while continuing past practices that have adversely affected anadromous salmon is a mistake. Such a delay only serves to increase the demise of salmon and their ecosystems.

B. *Nineteenth-Century Species Management and the Separation of Species from Natural Influences*

The nineteenth-century hatchery system is an example of how many nineteenth-century fish and wildlife managers tended to see inroads on fish and wildlife as individual problems with individual solutions. As development destroyed habitat and people overharvested fish, managers proposed using hatcheries to compensate for the damage.⁹ Hatcheries grow salmon from eggs in a protected environment and then release the hatched salmon into rivers where the salmon migrate to the sea. Early fishery scientists had broad ideas about the “plasticity” of salmon, misconceptions about salmon life histories, and ambitious expectations about human ability to improve on what was viewed as a wasteful natural world.¹⁰ Fishery managers thought that hatcheries could substitute for lost habitat and also support greater harvests.¹¹ Fishermen would have to save only enough adult fish to supply eggs to the hatchery—far fewer than the number of adults needed to spawn in a harsh and deteriorating natural environment. Hatcheries also appealed to policy makers.¹² Hatcheries allowed them to defer difficult political and economic choices.¹³ Instead of being forced to choose between fish and development, they could have both. Hatcheries served the interests of fish and wildlife managers, fishermen, and developers. The seeds of this wedding of interests were sown in the nineteenth-century, but the relationship grew throughout much of this century and still persists today, even in the face of controversy.¹⁴

National Research Council, *Upstream: Salmon and Society in the Pacific Northwest* 348 (1996) [hereinafter *Upstream*].

9. See Joseph E. Taylor, *Making Salmon: Economy, Culture and Science in the Oregon Fisheries, Precontact to 1960 at 107–19* (1996) (unpublished Ph.D. dissertation, Univ. of Wash.) (on file with University of Washington Library); see also *Upstream*, *supra* note 8, at 50.

10. See Taylor, *supra* note 9, at 125–26.

11. See *id.* at 107; see also Independent Scientific Group, *Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem* 378, 388 (prepublication copy Sept. 10, 1996) [hereinafter *Return to the River*].

12. See Taylor, *supra* note 9, at 151, 156.

13. See *id.* at 151.

14. Who is to say this was an unreasonable bargain? If the primary alternative is a resource policy based more closely on the character of the land, the 19th century offers another cautionary example. John Wesley Powell’s irrigation survey proposed to evaluate local hydrologic conditions in the West, identify the best irrigation sites, and provide a hydrologically rational basis for western development. The idea gained momentum within the government, but when it began actually to block development, there was a “perfect storm of indignation” and Congress squashed it. California

This mechanistic perspective was not limited to the hatchery system. During the 1950s, there was a major congressional debate whether to build any more dams on the Snake River or its tributaries. In addition to expressing confidence in "fish farming," proponents of dam development argued that dams, properly configured, would actually help make the river more productive:

We oppose S. 2586 on the grounds that it is too drastic and that it is premised on the pessimistic assumption that the problem of fish passage at high dams will never be solved.

We especially oppose section 2 which prohibits any dam which would flood "established spawning grounds." This is an absolute prohibition of all dams.

This provision alone is highly unreasonable and extreme since a new reservoir almost invariably has more shoreline and is more likely to provide new and more extensive shallow spawning waters than can be expected in the narrow, rock cradle of the turbulent, highly fluctuating Salmon River.

The Salmon River is far from being a perfect stream for raising fish. It is a flooder, with extremes of flow at White Bird ranging from 1,580 second-feet in December 1932 to 120,000 second-feet in June 1894. This is a range or erratic ratio of 76 to 1. Man should certainly be able to improve this reckless river into a better habitat for salmon.¹⁵

The premise for the mechanistic view of rivers was the idea that natural systems were the sum of known parts that could be "improved." Development could carve up natural systems, lose some parts, replace others with technological surrogates, and the system would still work, maybe even better. In the Snake River Basin, dams were built, and hatchery programs were created. However, the problem of fish passage at

v. United States, 438 U.S. 645, 659 (1978) (quoting 29 Cong. Rec. 1955 (1897)). Even though Powell's program was anything but an environmental initiative, Powell's was a piece of "ecological realism in an unsympathetic age." Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* 133 (1985). In the long history of conflict between conservationists and developers, the rough treatment Powell's program received has been a sobering tale.

15. *Columbia River Basin Fishery Resources: Hearing on S. Con. Res. 35, S. 2586, S. 1420 Before the Senate Comm. on Interstate and Foreign Commerce*, 86th Cong. 208 (1960).

high dams proved to be insurmountable,¹⁶ and hatchery compensation programs have been problematic.¹⁷ These difficulties laid the groundwork for the species conflicts of today.

In the Columbia River, the Puget Sound region, and other places, remedial efforts are based on mechanistic approaches. Hatcheries have replaced wild fish with hatchery fish to a large extent.¹⁸ Dams retrofitted with screens to keep fish out of turbines were successful in some places and disappointing in others.¹⁹ Managers of remedial fish and wildlife programs augmented stream flows with stored water, but the results were debatable.²⁰ Woody structures placed in streams to create resting areas for fish worked in some places, but washed out in others.²¹ We assumed that if we did enough of these things we could fix the problem. This idea has appeal in a political system that is disinclined to push restrictions on humans.

C. *The Endangered Species Act and Individual Species*

Notwithstanding the mechanistic programs, in the early 1990s the Endangered Species Act riveted the Columbia River region's attention on the question of what to do about wild salmon, particularly those that spawn in the Snake River. The problem, however, had deep roots. Salmon began their downward slide in the early part of this century.²² By

16. See Michael C. Blumm, *Hydropower vs. Salmon: The Struggle of the Pacific Northwest's Anadromous Fish Resources for a Peaceful Coexistence with the Federal Columbia River Power System*, 11 *Envtl. L.* 211, 240–41 (1981).

17. "In summary, the LSRCP Hatchery Program and the LSRCP mitigation efforts haven't been able [to] meet expectations and come close to the pre-dam target levels for adult chinook returns Although the steelhead picture is better, the post Lower Snake River dam project returns remain well below the pre-dam levels." Dan Herrig, *Lower Snake River Compensation Plan Background*, in *Lower Snake River Compensation Plan Status Review Symposium* 14, 18 (1998).

18. See Northwest Power Planning Council, *Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin*, app. D at 212 (1987) [hereinafter *Salmon and Steelhead Losses*]; Wilkinson & Conner, *supra* note 2, at 81–84.

19. See *Return to the River*, *supra* note 11, at 288–308; *Upstream*, *supra* note 8, at 238, 240.

20. See *Upstream*, *supra* note 8, at 246, 351.

21. See *id.* at 218–19.

22. Some scientists point to 1921 as the year in which Columbia River salmon began to decline. See *Return to the River*, *supra* note 11. But the matter is debatable. A number of salmon stocks were wiped out by overfishing in the late 19th century, and in 1894, a federal fisheries official said it was "beyond question" that the numbers of salmon returning to spawn were "insignificant in comparison with the number which some years ago annually visited and spawned in these waters." William Dietrich, *Northwest Passage: The Great Columbia River 188* (1995); see also U.S. Dep't of Agric.

the mid-1980s, the decline was far advanced. The Columbia River Basin runs were by the mid-1980s only about twenty-five percent wild,²³ by 1990, the wild populations seemed to be careening downhill. Decades of expanding hatchery programs meant that fishermen had grown to expect the large harvests that hatcheries fed.²⁴ At the same time, salmon populations were less diverse genetically, less adapted to their environment, more prone to disease, and apparently more vulnerable to changes in ocean conditions.²⁵ As hatchery production increased, the Basin was trading vigorous wild fish populations for dull-witted hatchery fish.²⁶ One prominent article reported that wild Pacific Coast salmon populations were at critically low numbers.²⁷ The message was in some ways surprising,²⁸ and in some ways not. Wild fish advocates had claimed for years that wild stocks were in trouble. The article simply documented the trend in a way that was impossible to ignore.

The Snake River populations were listed under the Endangered Species Act in the early 1990s.²⁹ However, there was an initial question whether Snake River salmon should be listed, given that other Columbia River populations remained viable: should Snake River populations be considered distinct from Columbia River populations for purposes of the Endangered Species Act? The Endangered Species Act defines "species" as "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which

& U.S. Dep't of the Interior, *Status of the Interior Columbia Basin: Summary of Scientific Findings* 46 (1996).

23. See Northwest Power Planning Council, *Columbia River Basin Fish and Wildlife Program* 7-13 (1994); *Salmon and Steelhead Losses*, *supra* note 18, app. D at 212; Wilkinson & Conner, *supra* note 2.

24. See *Upstream*, *supra* note 8, at 320; Michael Goodman, *Preserving the Genetic Diversity of Salmonid Stocks: A Call for Federal Regulation of Hatchery Programs*, 20 *Env'tl. L.* 111, 140-41 (1990); Wilkinson & Conner, *supra* note 2, at 81-83.

25. See *Upstream*, *supra* note 8, at 3, 18.

26. See Ray Hilborn, *Hatcheries and the Future of Salmon in the Northwest*, 17 *Fisheries* 5 (1992); Ray J. White et al., *Better Roles for Fish Stocking in Aquatic Resource Management*, 15 *Am. Fisheries Soc'y Symp.* 527, 530 (1995).

27. See Willa Nehlsen et al., *Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho and Washington*, 16 *Fisheries* No. 4 at 4 (1991).

28. See *infra* Part II.D.

29. See 50 C.F.R. § 222.23 (1998) (listing Snake River sockeye salmon as endangered); 50 C.F.R. § 227.4(g)-(h) (1998) (listing Snake River spring/summer and fall chinook salmon as threatened); 50 C.F.R. § 227.4(f)-(g) (1998) (listing Snake River spring/summer and fall chinook salmon as endangered).

interbreeds when mature.”³⁰ Interpreting this language, the National Marine Fisheries Service concluded that a local salmon population would qualify as a protected population segment if it were an “evolutionarily significant unit,” that is, a population that is important to the evolutionary process.³¹ The Snake River populations satisfied this test, and since then the Fisheries Service has geared the Act’s protective machinery toward these populations.

In the process, the Endangered Species Act delivered an ambiguous message regarding reliance on technology. While the Endangered Species Act is concerned with wild stocks, its administration has been oriented to specific salmon populations. This is not an inevitable result, but it does follow a larger pattern in the Act’s administration. One of the Endangered Species Act’s purposes is to “provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved.”³² For many years, however, this has been primarily a rhetorical principle, and critics contend that the Act actually diverts attention from the task of protecting ecological processes that support biodiversity.³³ For example, the National Marine Fisheries Service, which administers the Act for salmon, prescribes captive brood stock technology—the quintessential technological fix—for the weakest Snake River stocks.³⁴ Moreover, fish barging is still an important part of the Columbia River recovery program.³⁵ There is a rationale for these

30. 16 U.S.C. § 1532(16) (1994).

31. The concept is explained in Robin S. Waples, *Definition of “Species” Under the Endangered Species Act: Application to Pacific Salmon* 9 (1991).

32. 16 U.S.C. § 1531(b) (1994). Interagency consultation regulations require federal agencies to consider “the direct and indirect effects of [their] action[s] on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action.” 50 C.F.R. § 402.02 (1998).

33. See Holly Doremus, *Patching the Ark: Improving Legal Protection of Biological Diversity*, 18 *Ecology L.Q.* 265, 304–17 (1991); Goodman, *supra* note 24, at 148–55 (1990); Suzanne Winckler, *Stopgap Measures*, *Atlantic Monthly*, Jan. 1992, at 74, 78.

34. See National Marine Fisheries Serv., *Interim Standards for the Use of Captive Propagation Technology in Recovery of Anadromous Salmonids Listed Under the Endangered Species Act* 4 (1999).

35. See *American Rivers v. National Marine Fisheries Serv.*, 126 F.3d 1118 (9th Cir. 1997) (remanding for trial to allow environmental groups to challenge biological opinion that supported barging); *Northwest Resource Info. Ctr., Inc. v. National Marine Fisheries Serv.*, 56 F.3d 1060 (9th Cir. 1995) (upholding fish transportation against challenge under National Environmental Policy Act). To this point, there have been a small number of steelhead populations found to be jeopardized by hatchery operations. See National Marine Fisheries Serv., *Biological Opinion on Artificial Propagation in the Columbia River Basin* 137 (1999).

methods in the short term: the few remaining wild populations represent a unique genetic heritage and if a degraded natural environment is more dangerous for fish than technology, technology may make sense. But the short-term rationale does little to address the long-term question of whether we can create a hospitable environment for salmon.

D. Two Landmark Scientific Reports Urge More Reliance on Nature

Over the last twenty years or so, there has been incremental recognition that technological solutions need to work with natural functions rather than supplant them. However, before the mid-1990s, this idea had a muted voice in the Columbia River region. In the mid-1990s, two landmark reports pushed the idea to the foreground, where it began to reshape the debate over the river. This section reviews the two reports and their role in conservation efforts.

It is hard to convey just how suddenly the Columbia River/Endangered Species Act problem seemed to emerge in the 1990s. During the 1980s, parties involved in salmon conservation enjoyed big political and legal gains. Congress had enacted sweeping legislation, contending parties had negotiated domestic and international harvest agreements, and the federal hydropower system had committed large financial resources to fish and wildlife mitigation. As late as 1989, some observers were ready to declare victory;³⁶ salmon were on the upswing.³⁷ It was little more than a year later that an important article reported wild salmon stocks in critical conditions³⁸ and the Endangered Species Act process was engaged.³⁹

After the shock settled in, Congress asked the National Academy of Sciences to review the science underlying the salmon declines. In response, the National Research Council's Committee on Protection and Management of Pacific Northwest Anadromous Salmonids published a report in 1996 entitled *Upstream: Salmon and Society in the Pacific*

36. See Wilkinson, *supra* note 1, at 214.

37. "[R]ecent fishery data show that overall runs are increasing and that the previously endangered runs have stabilized." Michael B. Early & Egil Krogh, *Balancing Power Costs and Fisheries Values Under the Northwest Power Act*, 13 U. Puget Sound L. Rev. 281, 315 (1990) (citing K. Pratt & D. Chapman, *Progress Toward the Run Doubling Goal of the Northwest Power Planning Council* (1989)).

38. See *supra* notes 27-31 and accompanying text.

39. See *supra* note 29 and accompanying text.

Northwest.⁴⁰ The report emphasizes that the salmon problem is an ecosystem problem for which there is no single solution, no magic bullet that would lead to recovery.⁴¹ As the committee's chair put it, "The 'salmon problem' in the Pacific Northwest can be dealt with only if diverse interests work together on the many issues that unfold during the salmon's life-cycle."⁴² *Upstream* points out the limitations of many of the mitigation strategies that have been tried.⁴³ The report observes that some technologies appear to lessen fish mortality, but no combination of existing strategies adds up to recovery. Rather, the report contends that the Northwest region needs to restore a higher degree of natural ecological function to the Columbia River ecosystem for salmon to recover to self-sustaining levels.⁴⁴ The report also comments on the institutional fragmentation in the Columbia River's management regime.⁴⁵ The report notes that 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.⁴⁶

About a year later, a panel commissioned by the Northwest Power Planning Council to do a related review filed a report with a similar message. The report is entitled *Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem*,⁴⁷ and its verdict is even more dramatic: unless we can restore more ecological function to the Columbia River ecosystem, wild salmon face extinction over the next 50–100 years, and various technologies can do no more than delay the inevitable.⁴⁸ The report cautions us to look carefully for what is left and

40. *Upstream*, *supra* note 8.

41. *See id.* at 378.

42. National Research Council, *New Management Approaches Needed to Restore Pacific Salmon Populations* (Nov. 8, 1995) (press release quoting Dr. John Magnuson) (on file with author).

43. *See generally Upstream*, *supra* note 8.

44. *See id.* at 4.

45. *See id.* at 24, 139–40, 324–26, 358–59.

46. *See id.*

47. *Return to the River*, *supra* note 11. For two shorter summaries of the report, see Independent Scientific Group, *Scientific Issues in the Restoration of Salmonid Fishes in the Columbia River*, 24 *Fisheries* 10 (1999) [hereinafter *Scientific Issues*], and Independent Scientific Group, *Return to the River: An Ecological Vision for the Recovery of the Columbia River Salmon*, 28 *Envtl. L.* 503 (1998).

48. *See Return to the River*, *supra* note 11, at 5, 7.

find ways to restore and reconnect functioning elements of the ecosystem.⁴⁹

Upstream and *Return to the River* elaborate on these points in different ways, but both underscore three themes. First, they emphasize the importance of restoring more ecological function to the river and relying less on complex, expensive, and ultimately ineffective technologies.⁵⁰ Second, they recommend careful consideration of the population structure.⁵¹ Third, progress in restoration will be difficult to see due to unpredictable effects of the ocean.⁵²

1. *The Importance of an Ecologically Functioning ("Normative") River*

Return to the River illustrates its point with the metaphor of a "working river."⁵³ The contemporary working river (the industrial river) does the work of power generation, irrigation, flood control, and navigation, and it works because humans have simplified the river's complexity. The dams' storage capacity enables us to manage flow releases to respond to demand for electric energy, to protect against floods, and to float over the cataracts that once made the river so difficult to navigate. Dams have made the river simpler and more manageable. With hatcheries, barges, flow augmentation programs, turbine screens, and other mitigation programs, we have followed a similar path. We have simplified the salmon population into one that we release from hatcheries in time periods that fit harvest plans and minimize conflicts with hydropower generation. Over time, we have achieved a working river with more manageable species. In Richard White's words, the river has become an organic machine.⁵⁴

One of the problems, according to *Return to the River*, is that biologically productive rivers are complicated. They have braided channels, intricate hydrologic processes, and huge populations of insects. They have rapids and falls. They may flood and recede, change channels,

49. See *id.* at 5–6, 512.

50. See *id.* at 506–07; *Upstream*, *supra* note 8, at 6, 26–27.

51. See *Return to the River*, *supra* note 11, at 30, 444–45, 509; *Upstream*, *supra* note 8, at 97–98, 353–64, 370.

52. See *Return to the River*, *supra* note 11, at 463, 491; *Upstream*, *supra* note 8, at 39.

53. See generally *Return to the River*, *supra* note 11, at 5–8, 19–20, 511–20, for a discussion of the "normative river."

54. See Richard White, *The Organic Machine* 90 (1995); see also *Scientific Issues*, *supra* note 47, at 10.

and push sediment and gravel around. These more complex rivers are also “working rivers” because their natural functions work to transform energy into nutrients and support a rich diversity of species. If the Columbia were this kind of working river, there would be a resilient salmon population with many salmon stocks migrating at different times, returning to different habitats, and interacting in obscure and unpredictable ways.

Return to the River calls this complex working river a “normative river,” one that meets specific functional norms that are essential to productive salmon populations. In the report’s view of the world, we are spending hundreds of millions of dollars a year on fish and wildlife programs trying to make up for the work that the natural river could perform *gratis*. Whether or not a normative river makes sense industrially, *Return to the River* argues that the industrial river cannot work for salmon over the long run, even with the technological and other fixes we have devised over the last twenty years.

Return to the River does not, however, overdramatize the idea of a normative river. Although the report portrays a significant divide between the normative river and the river of today, the choice is in some ways less stark. The authors of the report took pains to emphasize that they are not arguing that a pristine system must be restored. Rather, they suggest movement *toward* normative conditions; the movement might be slow, fast, or somewhere in between. Next year’s river might not look much different from this year’s river. But *Return to the River* proposes a river ecosystem that, over time, has significantly healthier habitat, connects flowing streams, and supports diverse species.

2. *Ecological Communities, Metapopulations, and Core Populations*

The two reports make a second point: a species is part of an ecological community with its own population structure.⁵⁵ Species are linked to other flora and fauna, insects, and processes that inhabit the same part of the world; together they are “one humming community of co-operations and competitions.”⁵⁶ Both reports argue that if we are serious about restoring species, we need to be serious about these communities.⁵⁷

55. See *Return to the River*, *supra* note 11, at xviii, 508; *Upstream*, *supra* note 8, at 35–36.

56. Aldo Leopold, *A Sand County Almanac* 193 (1966).

57. See *Return to the River*, *supra* note 11, at 5, 511–12; *Upstream*, *supra* note 8, at 35–36.

The subtler point is that animal populations have unique structures. Ecologists think that even a single species is composed of interacting local populations that together comprise a metapopulation.⁵⁸ *Upstream* and *Return to the River* argue that we should begin to think of Columbia River salmon as metapopulations whose pre-development structure could illuminate the effectiveness of mitigation strategies.⁵⁹

The reports also say that for the most part, the Columbia's big salmon populations were primarily in the *mainstem* of the Columbia River and in the lower reaches of major tributaries.⁶⁰ These alluvial reaches were biologically rich areas that bred microorganisms and insects that fueled food chains. For salmon, these were the hot spots of productivity, the cores of the big pre-development salmon runs.⁶¹ When these alluvial core populations were strong, Columbia River salmon production was strong. These populations were different from the populations that spawned in higher tributary areas. Headwater spawners occupy less-favorable ecological niches—the farther from the alluvial core, the sparser the food supply, and the smaller the population. To some degree, the interconnections among populations are important. For example, if a mudslide wiped out a tributary population, the tributary might be recolonized from the mainstem. If a mainstem population thinned, it might be fed from the headwaters. However, the alluvial core is a vital component: the bigger the core, the more resilient the population overall.

For many years, Columbia River recovery efforts have focused on the smaller tributary populations in headwater areas. This is because these populations are almost the only populations we have left; development has mostly eradicated mainstem core populations. But the irony is that salmon conservation programs are likely to be fragile unless they resuscitate core populations in alluvial reaches. Whether the objective is long-term sustainability or rebuilding harvestable runs, a large mainstem core population is important.

One of the problems with basing salmon recovery on core populations in alluvial areas is that people and salmon both prefer productive, alluvial country. Cities like Portland, Yakima, and Pendleton are in alluvial areas. A great deal of irrigated farming and grazing occurs in alluvial plains. Big dams in the river's mainstem inundate or block alluvial river reaches.

58. See *Return to the River*, *supra* note 11, at 29–30.

59. See *id.*; *Upstream*, *supra* note 8, at 97–98, 363–64, 370.

60. See *Return to the River*, *supra* note 11, at 445, 509; *Upstream*, *supra* note 8 at 97–98.

61. See *Return to the River*, *supra* note 11, at 30.

Salmon were pushed out of these areas, and the salmon that are left generally spawn elsewhere—some in hatcheries, some in headwater areas.

There are, however, some alluvial populations left. Upriver bright fall chinook spawn in the last free-flowing stretch of the Columbia, upstream of the Columbia-Snake confluence in south central Washington.⁶² The “brights” are now the biggest naturally spawning segment of the Columbia runs, one of the few populations that might still serve as a core. Ironically, they spawn in the Hanford Nuclear Reservation, which is the site of stored nuclear waste that may seep into the Columbia some day. Nonetheless, if we are looking for an area in which to rebuild a core population to interact with tributary populations, *Return to the River* suggests that building out from the Hanford Reach area is an obvious way to start.⁶³

3. *Overwhelming Uncertainty in the Ocean*

Finally, after suggesting the possibility of an ecologically structured approach to species recovery, *Upstream* emphasizes the difficulty of determining whether specific recovery measures were effective, and traces much of this problem to the ocean.⁶⁴ What happens in the ocean plays a critical role in the status of salmon stocks. If ocean conditions are unfavorable to Columbia River stocks, fewer salmon will return to spawn. If ocean conditions are favorable, salmon stocks will thrive. How can we distinguish the effects of ocean conditions, which fluctuate from year to year, from the effects of salmon recovery efforts? For example, *Upstream* posits that the apparent effectiveness of hatcheries might have resulted from favorable ocean and climatic conditions during the period when hatcheries were built, and conversely, the decline of some populations might have resulted from introducing new hatchery populations into an ocean pasture of limited capacity.⁶⁵

The uncertainty stemming from the ocean has stark implications for policy. One of the best examples is described in Arthur McEvoy’s study

62. See *Return to the River*, *supra* note 11, at 31.

63. See *id.* at xx, 31, 519.

64. See *Upstream*, *supra* note 8, at 39.

65. See *id.* at 45.

of the pelagic (open-sea) fisheries collapse in California.⁶⁶ During the second half of the nineteenth century, abalone off the California coast were abundant because fur traders had slaughtered the otter that preyed on abalone.⁶⁷ But when climatic factors later caused abalone and other species to decline, white fishermen accused the Chinese of depleting the fisheries and drove them from the fishing grounds.⁶⁸ Actually, the Chinese had helped other fisheries because their elimination of abalone had increased the growth of kelp, thereby augmenting the food supply for other fish.⁶⁹ As fish populations increased at the end of the century, white fishermen attributed it to their success in driving the Chinese away.⁷⁰ In short, ecological, social, and environmental changes interacted to affect humans who never understood the consequences of their own actions.⁷¹ Similar hazards arise in the Columbia River salmon debate. Uncertainties over cause and effect create rich opportunities for misunderstanding, inequity, and error. *Upstream* notes that ocean ecology has long been an area of “deep ignorance,” and we are only beginning to consider how to contend with it.⁷²

In dealing with these uncertainties, it is worth remembering a caution mentioned earlier in this Article: ecological science, like atmospheric science and economics, deals in “broad-brush analysis, illustration of mechanisms, and short-term predictions” rather than in precise answers.⁷³ This should by no means imply that ecological science is not useful. Many areas of science, such as quantum physics, are inexact.⁷⁴ When we consider questions of species conservation, we can make statistical predictions and broad estimates, but often we cannot make precise predictions or explain the forces that affect specific outcomes.

66. See Arthur F. McEvoy, *The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850-1980* (1986).

67. See *id.* at 79, 81.

68. See Richard White, *It's Your Misfortune and None of My Own* 15 (1991).

69. See *id.*

70. See *id.*

71. See *id.* at 214–15.

72. *Upstream*, *supra* note 8, at 45.

73. Lewis, *supra* note 7 and accompanying text.

74. Quantum physics assumes that events in the atomic realm do not occur deterministically, but rather, probabilistically. We cannot accurately predict the behavior of atomic particles. Any given electron might jump this way or that, and physicists can only ascribe a probability to the outcome. Events are predictable only in a more generalized, statistical sense. See Richard Feynman et al., *The Feynman Lectures on Physics: Quantum Mechanics* 2-8 to 2-9 (1966).

Upstream and *Return to the River* are mixtures of insight, guidance, and cautions, but most importantly, they lead to a central question: how can a developed ecosystem move toward greater ecological function when the wild ecosystem has vanished and been replaced by one that is reengineered to meet the demands of a large, growing human population?

The question arrives at an interesting moment. The National Marine Fisheries Service is poised to write a new biological opinion on whether the federal Columbia River hydropower system jeopardizes listed Snake River salmon. The opinion is expected to address the so-called "configuration" issue surrounding the Lower Snake River dams. Configuration involves the question of whether removing the earthen parts of those dams and restoring the Lower Snake to a free-flowing condition would play a key role in recovery. Restoring free-flowing conditions by removing dams sounds like a step toward *Return to the River's* normative conditions. But whether removing these dams for these species is appropriate in light of competing human values, is a mixed question of science, law, and policy.

Although this federal process has focused on Snake River salmon, the Snake River stocks represent a relatively narrow subset of a large, interrelated set of populations. *Upstream* and *Return to the River* suggest a broader focus in which underlying ecological processes are central and the structure of salmon metapopulations is important.⁷⁵ Thus, our vision is still too simplistic, and the list of things we do not know is still long and growing even as we learn. Making decisions will require us to account for phenomena on which science still sheds limited light. The next section discusses ways to manage in this obscurity.

III. MANAGING UNCERTAINTY: TOOLS FOR SPECIES CONSERVATION

Policy makers will be able to make intelligent decisions in conservation policy only if they understand the conservation tools available to them, including those used for managing uncertainties that surround complex conservation problems. In the Columbia River effort, conservation methods are still evolving, but the risk management toolbox is much larger than it was even ten years ago. Many of the methods

⁷⁵ See *Return to the River*, *supra* note 11, at 5–6, 30, 445, 509, 512; *Upstream*, *supra* note 8, at 6, 26–27, 39, 97–98, 363–64, 370.

represent efforts to implement a scientific management approach called adaptive management, which recognizes that conservation initiatives are often more experimental than proven. With the assumption that no conservation measure will *necessarily* work, Columbia Basin managers have used four tools in particular: applied research into important but narrow questions; collaborative computer simulations to test hypotheses and identify key uncertainties; independent boards of scientists to synthesize scientific knowledge; and ecology-based analysis to inform policy debates' broad goals and management frameworks. As discussed later in this Article, none of these techniques has yet succeeded in creating a systematic approach to experimentation. They are, however, bringing scientists and policy makers closer to adaptive management's goals of acting in the face of uncertainty, and learning from that action.

A. *Adaptive Management*

By the 1980s, there was plain evidence that mitigation programs were not countering population declines. Kai Lee, a University of Washington professor who was then a member of the Northwest Power Planning Council, argued that traditional fish and wildlife mitigation efforts had in many cases either failed or produced unintended results.⁷⁶ Drawing on the work of C.S. Holling, Carl Walters, and others,⁷⁷ Lee and his colleague, Jody Lawrence, urged that this simply required policy makers to depart from traditional assumptions and adopt an approach called adaptive management.⁷⁸ This approach asserts that because natural systems are much more complex and unpredictable than traditional management acknowledges, all fish and wildlife management efforts are intrinsically experimental.⁷⁹ Drawing from this idea, Lee urged "a simple

76. See, e.g., Lee & Lawrence, *supra* note 2, at 440 n.40.

77. See *Adaptive Environmental Assessment and Management* (C.S. Holling ed., 1978); Carl Walters, *Adaptive Management of Renewable Resources* (1986).

78. See Lee & Lawrence, *supra* note 2.

79. See *Compass and Gyroscope*, *supra* note 1, at 9; Lee & Lawrence, *supra* note 2, at 443; Willis McConaha & Peter Paquet, *Adaptive Strategies for the Management of Ecosystems: The Columbia River Experience*, in *Multidimensional Approaches to Reservoir Fisheries Management*, 16 *Am. Fisheries Soc'y Symp.* 410, 410-12 (Leandro E. Miranda & Dennis R. DeVries eds., 1996); John M. Volkman & Willis McConaha, *Through a Glass, Darkly: Columbia River Salmon, the Endangered Species Act, and Adaptive Management*, 23 *Envtl. L.* 1249, 1255 (1993). Chapter 13 of *Upstream*, *supra* note 8, puts adaptive management on the Columbia River into a useful institutional context.

imperative: policies are experiments; *learn from them*.”⁸⁰ We are almost invariably going to be surprised by the results of what we do. We should treat conservation initiatives as hypotheses and learn from them.⁸¹

Adaptive management has several nuances. First, unlike traditional management regimes, it does not assume the effectiveness of existing programs. Adaptive management requires skepticism about existing programs, an active search for the assumptions underlying these programs, and a commitment to test them. Where objectives such as maximum sustainable harvest drive traditional programs, the potential for learning drives adaptive management. Where management practices drive existing programs, experimental observation drives adaptive management. Rather than professing certainty, adaptive management begins in doubt, trusting only experimental evidence.

The second premise of adaptive management is that we can learn from management programs only if they have measurable results. Whether we can measure the effects of a given action depends on its ecological context, but in many instances only dramatic action can produce a measurable response in an ecosystem. Adaptive management does not call just for experimentation, but for experimentation that generates a measurable response.

A third premise of adaptive management is that to have any hope of producing experimentally significant results in a developed ecosystem, experimentation must account for its social context. Because ecosystems have extensive ties to human communities, the prospect of bold experimentation implies significant human impacts. Actions with significant human impacts must pass a variety of legal and political tests. Interested parties need to participate in considering potential experiments, come to an understanding of what is known and unknown, and decide what might make a significant difference to species. Adaptive management has been applied largely in the harvest arena, where experimentation requires cooperation with fisheries, which need to be convinced of the value of dramatic closures.⁸² In this sense, the concept of adaptive management raises a the question whether we can devise

80. *Compass and Gyroscope*, *supra* note 1, at 9.

81. See Lee & Lawrence, *supra* note 2, at 443.

82. See Murdoch K. McAllister & Randall M. Peterman, *Experimental Design in the Management of Fisheries*, 12 N. Am. J. Fisheries Mgmt. 1, 15–16 (1992); see also Jeremy S. Collie & Carl J. Walters, *Adaptive Management of Spatially Replicated Groundfish Populations*, 48 Canadian J. Fisheries & Aquatic Sci. 1273 (1991); Carl J. Walters & Ray Hilborn, *Adaptive Control of Fishing Systems*, 33 J. Fisheries Res. Board Can. 145 (1976).

meaningful experiments when we temper them with legal and political considerations.

Finally, adaptive management uses computer models to structure a learning process. The process begins with an effort to integrate experience and information into models that attempt to make predictions about the effects of alternative actions. In building such a model, analysts usually must integrate a mass of disparate information. They must clarify the nature of the problem, discard unpromising management options, and identify critical knowledge gaps to address through experimentation.⁸³

Since the mid-1980s, scientists, policy makers, and fish and wildlife managers in the Columbia River have endorsed the concept of adaptive management to manage uncertainty. The concept is promising for clarifying scientific knowledge, measuring progress toward conservation goals, and using a collaborative process. The next sections describe how the concept of adaptive management has played out in the Columbia River salmon conservation effort.

B. *Four Ways to Learn*

The Columbia River conservation effort has involved four policy-learning tools: applied research, collaborative computer modeling, independent science boards, and development of an ecologically oriented policy framework. These tools have emerged not from a single process, but from the separate efforts of a variety of parties. The tools have not evolved in a manner that we could have predicted, and this unpredictability is a central characteristic of the Columbia River parties' efforts to learn from the implementation of conservation policy.

1. *Applied Research: Big Questions, Narrow Answers*

When species conservation initiatives affect humans, policy makers want scientific answers that gauge human impacts and support nuanced solutions that leave whole as many interests as possible. However, the broad-brush science of ecology has little to say about these nuances. In theory, adaptive management experiments should afford a way to generate more targeted answers and assist decisionmaking.

83. See Carl J. Walters, *Challenges in Adaptive Management of Riparian and Coastal Ecosystems*, 1 *Conservation Ecology* 1 (December 1997) <<http://www.consecol.org/vol1/iss2/art1>>.

In the Columbia River Basin, policy makers and researchers developed a program of applied research to test mitigation measures. For much of the last two decades, the debate over mitigation methods has focused on addressing the effects of mainstem dams, emphasizing costly methods such as flow augmentation, spill programs, and mechanical bypass systems at the dams. These measures drew attention because hydropower dams have played a big role in salmon declines and mitigating these effects is costly. Current costs for mitigation measures run into the millions of dollars. They include repaying the cost of capital investments in mitigation technology and the revenue effects of measures such as flow augmentation and spill, which depend on runoff, energy market conditions, and other assumptions.⁸⁴ There is undeniable interest in finding out whether the investment in these measures is well spent.

One of the biggest controversies in this collection of measures is the effect of flow augmentation on salmon survival in the Columbia and Snake Rivers. Since the early 1980s, conservation programs have released water from headwater storage reservoirs to augment the flow of these rivers for salmon. To some people, the logic of the flow augmentation program is perfectly obvious: salmon need water and the more, the better. But the reason why increased flows might help salmon is more complex. The Columbia and Snake are big rivers. They do not need more water to keep from drying up. Rather, if more water is useful, it is because it changes the rivers' ecology for the better. Flow augmentation may help if the problem is that the rivers run too slowly to get juvenile salmon to the estuary consistent with the tick of a biological clock. Increased flows may help to eliminate conditions favoring fish that prey on salmon. Increased flows may replicate the spring freshet that the dams eliminated, and push fresh water into the ocean. But if none of these factors is a real problem for salmon, or if the problems are so large that flow augmentation does nothing for them, the investment may be better spent on less costly measures like fish barging or more controversial steps like dam removal.

There has been hot dispute over flow augmentation proposals for many years, but biological data have been sparse. Data collected between 1973–79 tend to support the idea that increased flows help juvenile

84. Capital costs and a high valuation of operational costs are described in Bonneville Power Administration, *White Paper: What is BPA Spending for Fish and Wildlife?* (March 1998). Other analysts put operational costs lower than Bonneville does. Personal Communication with John Fazio, Northwest Power Planning Council, in Portland, Or. (Feb. 18, 1999).

salmon in their spring migration in low-water years.⁸⁵ But the data are unclear about the benefits in wetter years, and there are questions about the data's relevance for today's river. Information on fish barging also has been the subject of fierce argument, and finding a way to generate better information on either conservation method has been contentious.

It took a full ten years before researchers could implement a new research program.⁸⁶ And even then, the result was not a bold management experiment in which key variables were manipulated. Instead, researchers monitored the survival of salmon that used different means of downriver passage, such as passing through reservoirs, or being collected and barged around dams. The research program, begun in the early 1990s and still underway, uses new technology for tagging fish with computer chips. The chips are called "PIT-tags," and they allow the identification of the individual fish at certain points in the downstream migration. The resulting data, while still preliminary, seem to show several things: (1) juvenile spring chinook salmon are surviving through the four Lower Snake projects far better than was previously thought; (2) transported fish survive barging well,⁸⁷ and (3) based on a year's study of a limited stretch of the river, the relationship between flow and survival is much more convincing for summer-migrating fish than for spring-migrating fish.⁸⁸

Unfortunately, the PIT-tag research answers only some questions and raises others. The unexpectedly high survival of juvenile fish through the four Lower Snake projects is certainly important. But if we are losing so few young fish in these reservoirs, why are returns of adult salmon to Snake Basin spawning grounds continuing to decline at such a rate? Some people insist that the problem can only be elsewhere in the system—poor habitat, adverse ocean conditions, competition from hatchery fish, predators, or other perhaps unknowable factors.⁸⁹ Others

85. See Carl W. Sims & Frank J. Ossiander, *Migrations of Juvenile Chinook Salmon and Steelhead Trout in the Snake River Basin from 1973 Through 1979: A Research Summary* 19–21 (1981).

86. See Volkman & McConnaha, *supra* note 79, at 1259–61.

87. See Northwest Fisheries Science Ctr., National Oceanic and Atmospheric Admin., *An Assessment of the Lower Snake River Hydrosystem Alternatives on Survival and Recovery of Snake River Salmonids*, Appendix to the U.S. Army Corps of Engineers, *Lower Snake River Juvenile Salmonid Migration Feasibility Study* at 3 (1999) [hereinafter *Assessment*].

88. See Bill Muir, National Marine Fisheries Serv., Address to the Northwest Power Planning Council (Jan. 12, 1999).

89. See James J. Anderson, Assoc. Professor, Sch. of Fisheries, U. of Wash., Testimony Before the U.S. Senate Subcomm. on Water and Power (Apr. 6, 1999) (on file with author).

say the declines are due at least in part to the delayed effects of the dams, which the PIT-tag research does not measure. No one can say if any of these explanations is right, and the PIT-tag data fail to resolve the question. The truth may be that the problem is more complex than the PIT-tag research alone can penetrate. This underscores the need for a broader framework for research and analysis.

2. *Computer Modeling and the PATH Project*

One of the suggestions of adaptive management is that computer models can help describe a comprehensive framework in which to understand ecological relationships. Models can provide a range of groups with an understandable body of information and identify interactions among key variables throughout the system. Such a tool could, for example, help compensate for the narrowness of the PIT-tag data, allowing us to see that study's results in a broader ecosystem context.

A project called the Process for Analyzing and Testing Hypotheses (PATH) uses computer models to test hypotheses regarding the decline of Snake River salmon and to sketch out management experiments with which to probe uncertainties.⁹⁰ The project has had broad participation.⁹¹ The Bonneville Power Administration funds the project at the request of the National Marine Fisheries Service, which took a court's advice to involve a broader range of parties in developing its biological opinion on hydropower impacts.⁹² The project has even older roots in a collaborative analytical program begun by the Northwest Power Planning Council in the 1980s. The project brings together a diverse group of technical analysts to review data and identify alternative explanations and potential solutions for salmon declines.⁹³ Analysts treat these explanations as

90. See D. Marmorek & C. Peters, *An Overview of PATH and Retrospective Analyses* at 2.

91. See *Plan for Analyzing and Testing Hypotheses (PATH), Final Report for Fiscal Year 1998* (D. Marmorek et al. eds., 1998).

92. In 1994, a court set aside the Fisheries Service's biological opinion on the effects of the hydropower system. A court counseled the federal parties to open up the closed process in which the biological opinion had been developed, to ensure that state fish and wildlife agency and tribal scientists were heard: "[T]he underlying root of the litigation problem is the feeling of these parties that the federal government is simply not listening to them." *Idaho Dep't of Fish & Game v. National Marine Fisheries Serv.*, 850 F. Supp. 886, 900 (D. Or. 1994).

93. Perhaps the best general description of the PATH process is in Northwest Power Planning Council & National Marine Fisheries Serv., *Technological Forum on PATH*, Meeting notes (Feb. 25, 1999) (on file with author).

hypotheses and run them through computer simulations. If a hypothesis produces results that approximate historical data, this would lend support to the hypothesis. Conversely, an inconsistency with historical data would weaken the hypothesis. Over time, PATH sifts hypotheses through the models, narrowing the range of plausible explanations and inferences about potential solutions.

It would be hard to overstate the care with which the PATH facilitators run the process. PATH surveys any hypothesis that its large and diverse group of analysts care to offer.⁹⁴ The analysts create “decision trees” on which they map out these alternative explanations.⁹⁵ These trees bring order to hypothetical causes and effects, but reach a daunting level of complexity. Where there are disagreements over analytical models, PATH incorporates alternative analyses using multiple models and uses the results to test the efficacy of the models.⁹⁶

In the fall of 1998, after several years of work, PATH prepared a “weight-of-evidence” report that summarized the analyses, supplemented with materials that divergent analysts thought would present a fairer picture.⁹⁷ PATH presented the materials to a Scientific Review Panel, composed of four respected scientists from outside the Columbia River Basin. The Review Panel evaluated the evidence and issued its own report, ascribing weights and probabilities to competing hypotheses, models, and potential solutions.⁹⁸ The use of computer models simulating salmon migration through the hydropower system has generated a great deal of controversy in the last decade, and the Panel expressed concerns about these models.⁹⁹ They found the models to be “adequate” for some purposes and not for others, but gave more credence to one model.¹⁰⁰ On the question whether the weight of the evidence supported any given management action, the Review Panel concluded that taking out the four

94. *See id.* at 4.

95. *See id.*

96. *See Assessment, supra* note 87, at 10–11; *see also Plan for Analyzing and Testing Hypotheses (PATH), Final Report for Fiscal Year 1998* (D. Marmorek et al. eds., 1998).

97. *See* PATH Scientific Review Panel, *Conclusions and Recommendations from the PATH Weight of Evidence Workshop* 8–11, 21 (1998) (held September 8–10, 1998, in Vancouver, B.C., Canada).

98. *See id.*

99. *See id.* at 21.

100. *See id.* at 8–11, 21.

Lower Snake dams would likely enable Snake River spring chinook to reach Endangered Species Act recovery thresholds.¹⁰¹

The Review Panel's report generated an electric reaction when it first came out. To some, the idea that removing these dams could make such a large difference was inconsistent with the PIT-tag data showing good salmon survival rates at the same dams.¹⁰² One PATH participant—the primary developer of the disfavored computer model—publicly criticized the Review Panel's report and complained about the “dysfunctionality of the PATH family.”¹⁰³ Other parties portrayed the Review Panel's report as a definitive resolution of the scientific issues, ignoring the Review Panel's caveats and disclaimers.¹⁰⁴ They contended that the Review Panel's conclusions were perfectly consistent with the PIT-tag data. The dams could have had effects that the PIT-tag research did not measure. For example, the dams could cause delayed mortality.¹⁰⁵ Eliminating the dams would also save adults that cannot find fish ladders as they migrate upstream.

In April, the National Marine Fisheries Service issued an analysis discussing the PATH results and the PIT-tag data. It concluded that removing the four dams would help.¹⁰⁶ However, the analysis noted substantial uncertainty about whether dam removal was necessary for recovery.¹⁰⁷ The disagreement continues to boil.

Because the process of analyzing data was so exhaustive, PATH spent little time discussing how the Basin might undertake experiments to clarify remaining uncertainties. Accordingly, the Review Panel report could comment only generally on three possible experimental manipulations: dam removal, elimination or substantial reduction of hatchery releases, and ending barge transportation.¹⁰⁸ The Review Panel outlined two ways to approach experimentation: take the cheapest action first, monitor the effects, and then take progressively more costly steps; or

101. *See id.* at 17.

102. *See* Margaret Hollenbach, *Reactions Mixed to Path's Progress Report*, 26 Columbia Basin Bull. 2 (Dec. 14–18, 1998) <http://www.nwppc.org/bulletin/bull_26.htm>.

103. *PATH Report Flawed, Says Major Participant*, 862 Clearing Up 10 (Jan. 25, 1999) (quoting Jim Anderson, consultant to Bonneville Power Administration).

104. *See* Hollenbach, *supra* note 102.

105. *See Assessment*, *supra* note 87, at 101.

106. *See id.* at 4, 6, 105.

107. *See id.* at 6–7.

108. *See id.* at 8–10.

take all the actions at once and then turn each one back on and evaluate the results.¹⁰⁹

This discussion of turning large human developments "off" or "on" illustrates the adaptive management paradox: in a large ecosystem, experiments must be large enough to produce measurable changes, but will entail large risk and expense. Gauging how far experiments have to go to be informative is largely a scientific question, but judging how far they can go before they trigger legal or political land mines is not. The experimental manipulations the report mentions are likely to trigger many responses. The PATH process can lay the groundwork for these questions, but has only begun to do so. In the meantime, the political debate will continue to take its course.

The PATH process also illustrates some of the hazards of scientists and policy makers working together on controversial matters. The Review Panel's report cannot be faulted for a lack of disclaimers. It states, for example, that ecological processes are poorly understood, that the data are spotty, that the models are crude, that research is needed, but that the weight of the evidence tends to favor a certain option. In political processes, however, such disclaimers do little to soften the political implications of an opinion that cuts for or against certain values. The fact that policy makers want independent, authoritative scientific opinion based on careful analysis and collaboration does not mean that they will welcome the results.

PATH also offers troubling lessons for those who hope for quick, penetrating insights from bold experiments. PATH is slow and expensive. We have only the broadest notion of an experimental program, and no real idea of how one could turn large human systems on or off. If ecosystem experimentation is to be part of practical management, it will have to move quickly and with less extraordinary ecological manipulations. But this renews the hard questions that underlie adaptive management, such as whether experimentation can move quickly and still bring along a critical mass of interested parties, and whether less ambitious experimental manipulations can generate measurable results in meaningful time frames.

Finally, *Upstream* and *Return to the River* raise questions about the PATH report and the PIT-tag data. PATH is concerned primarily with certain groups of Snake River salmon, particularly those that spawn in

109. See *id.* at 28.

tributary headwaters.¹¹⁰ The models that PATH uses treat the ecosystem as having on and off switches for certain sources of salmon mortality.¹¹¹ The PIT-tag data represent some of those switches. The questions PATH asks are Endangered Species Act questions, such as whether we can recover species to the relatively low levels that would allow them to be removed from the endangered species list. The PATH Scientific Review Panel's report concludes that we can probably recover this small collection of species to the point that they no longer belong on the endangered species list, but only by taking some fairly heroic steps.¹¹² *Return to the River* and *Upstream* suggest quite a different objective: creating a hardy, interacting set of metapopulations.¹¹³ Such an objective represents a shift in perspective toward larger population structure, reestablishing mainstem core populations, and protecting ecological processes that such a structure implies. The models used in PATH have no switches for these factors.

One further lesson from PATH, then, is that even when we frame careful, densely analytical collaborative processes, they are ultimately rooted in how we see the world. As this perspective changes from one person to another, the number of hypotheses and the potential for controversy multiplies. As perspective shifts with new scientific insights like those of *Upstream* and *Return to the River*, the very process of analysis must adapt to a new landscape. In both ways, ecological processes are refracted through imperfect human lenses. Limitations in human understanding of such systems are some of the most compelling reasons to look to experimental learning. Experimentation can help us to learn from systems we do not understand. Yet, PATH illustrates how hard it can be even to discuss experimenting with well-developed ecosystems.

3. *Independent Science*

A useful species conservation policy must begin with a scientific picture of the relevant ecosystem, but scientific perspectives vary among different stakeholders. For many years, Columbia River Basin conservation efforts were based on battling scientific experts, having

110. *See id.* at 1.

111. *See id.* at 10–13.

112. *See id.* at 17.

113. *See supra* notes 55–63 and accompanying text.

varying degrees of legal authority. Several laws accord fish and wildlife managers special status in interpreting scientific information and setting mitigation policy in the Columbia. The Endangered Species Act requires the National Marine Fisheries Service to make scientific judgments regarding listed ocean-migrating fish; the U.S. Fish and Wildlife Service plays this role for other species.¹¹⁴ The Northwest Power Act requires the Northwest Power Planning Council to give “due weight to the recommendations, expertise, and legal rights and responsibilities” of tribes and of fish and wildlife managers when the Council writes its fish and wildlife program.¹¹⁵ While the Council must create program measures based on the “best available scientific knowledge,”¹¹⁶ one court has said that this judgment is also one that fish and wildlife managers should heavily influence.¹¹⁷ Legally, then, fish and wildlife agencies and tribes are important interpreters of scientific knowledge.

In the early 1990s, policy makers saw the need for a more independent scientific perspective. Notwithstanding a big investment in rebuilding fish and wildlife, salmon were still declining and no one could demonstrate what difference mitigation efforts, guided largely by fish and wildlife managers, were making. The traditional fish and wildlife management perspective no longer seemed to fit very well in the Endangered Species Act era. Developing fish and wildlife programs to meet the needs of harvest managers rang off-key in a regime that was concerned first and foremost with the survival of wild species. Moreover, fish and wildlife initiatives in the 1980s were based on diverse management agendas rather than on an integrated conception of the river.¹¹⁸ No single agency had brought the breadth of vision, the scientific expertise, and the authority to bear in developing an integrated view of the Basin.

Congress issued the first request for an independent scientific perspective in 1992, and later others did the same. At Senator Hatfield’s behest, Congress asked the National Academy of Sciences to review “the status of existing wild stocks and their habitat, genetic characteristics and histories of the stocks, hatchery and production strategies, federal and

114. See 16 U.S.C. § 1532(15) (1994).

115. 16 U.S.C. § 839b(h)(7) (1994).

116. 16 U.S.C. § 839b(h)(6)(B) (1994).

117. See *Northwest Resource Info. Ctr., Inc. v. Northwest Power Planning Council*, 35 F.3d 1371, 1391 (9th Cir. 1994).

118. See *Scientific Issues*, *supra* note 47, at 11.

state anadromous fisheries management practices, and [to make] recommendations to improve the prospects for long-term sustainability of the species.”¹¹⁹ Three years later, in 1995, the National Academy committee circulated a draft of its report, *Upstream: Salmon and Society in the Pacific Northwest*. It released the final version one year later. The report had an entire chapter urging the creation of an independent science board to ensure that research is “objective, focused on the most important problems, scientifically sound, and free of political or policy bias.”¹²⁰ The National Marine Fisheries Service and the Northwest Power Planning Council had already begun thinking along these lines. The Council’s fish and wildlife program called for such a group,¹²¹ as did the National Marine Fisheries Service’s 1994 proposed recovery plan.¹²² Finally, *Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem*, which came out in 1996, delivered a stinging critique of the ways in which a collection of fish and wildlife mitigation measures, each supported by a different management agency, could detract from an integrated view of the ecosystem.¹²³ The criticism was consistent with the idea of an independent science board that could bring a more integrated and objective perspective to the problem of species conservation. The Northwest Power Planning Council and the National Marine Fisheries Service created the Independent Scientific Advisory Board (ISAB) in early 1996.

Given the obscure boundary between policy and science in the Columbia region, the organization of the science board deserved thought. As the PATH process demonstrates, the Columbia River issues involve such high stakes that any clearly articulated opinion, scientific or not, is likely to provoke criticism or suspicion of bias. Organizational structure can influence this tendency positively or negatively. For example, a neutral party facilitates PATH, and the process has some independent scientific oversight. However, one of PATH’s primary aims is to allow contending analysts to do much of the work. This arrangement can build

119. National Research Council Comm’n on Life Sciences, National Academy of Sciences, Protection and Management of the Pacific Northwest Anadromous Salmonids 1 (Oct. 1992) (unpublished, on file with author).

120. *Upstream*, *supra* note 8, at 353.

121. See Northwest Power Planning Council, *Columbia River Basin Fish and Wildlife Program* § 3.20B.1, at 3-9 (1994).

122. See National Oceanic & Atmospheric Admin., *Proposed Recovery Plan for Snake River Salmon* at III-7 (1995).

123. See *Return to the River*, *supra* note 11, at 43–45.

understanding, but it can also afford the opportunity for opposing analysts to work the process to their own advantage. In contrast, the science board created by the Council and the Fisheries Service is intended to be independent and perceived to be independent. Because it would not involve interested parties, such a science board may offer less opportunity to build understanding among competing parties. However, it can build trust through careful work, persuasive analysis, and independence. The challenge is in creating a board with real independence, but with the ability to provide advice that responds to agencies' policy mandates.

The ISAB structure meets this challenge in several ways.¹²⁴ First, two different agencies, the National Marine Fisheries Service and the Northwest Power Planning Council, choose the board's members.¹²⁵ The agencies have separate missions, political constituencies, and responsibilities, which reduce the potential for one agency or the other to skew the board to a political agenda. Under the Endangered Species Act, the federal Fisheries Service focuses on the needs of listed species, including how they are affected by land and water management systems.¹²⁶ On the other hand, under the Northwest Power Act, the Northwest Power Planning Council, a four-state council, must accommodate a very different constellation of interests, including a broader range of fish and wildlife; a narrower range of effects on fish and wildlife (the effects from hydropower development); the region's need for an adequate, efficient, economical, and reliable power supply; the activities of fish and wildlife managers and Indian tribes; and the administrative and financial constraints of the federal hydropower system.¹²⁷ The balance of power between the two agencies reduces the chance that one agency could push the ISAB in a political direction.

A second characteristic that helps ensure the ISAB's independence is the way in which the two agencies choose the board's members. The

124. The board's structure and operations are specified in two documents. See Northwest Power Planning Council & National Marine Fisheries Serv., *Agreement Regarding the Independent Scientific Advisory Board* (1996) [hereinafter *Agreement Regarding the Independent Scientific Advisory Board*]; Northwest Power Planning Council & National Marine Fisheries Serv., *Independent Scientific Advisory Board Terms of Reference* (1996).

125. See *Agreement Regarding the Independent Scientific Advisory Board*, *supra* note 124, at 2.

126. See 16 U.S.C. § 1531(b) (1994) (protection of ecosystems); see also *Palila v. Hawaii Dep't of Land & Natural Resources*, 649 F. Supp. 1070 (D. Haw. 1986) (land); D. Tarlock, *The Endangered Species Act and Western Water Rights*, 20 Land & Water L. Rev. 1 (1985).

127. See Northwest Power Act, 16 U.S.C. § 839b(h) (1994).

Fisheries Service and the Council took pains to insulate the process of selecting the board's membership. Any party in the region can nominate a scientist to serve on the science board.¹²⁸ However, nominations go to a selection committee composed of independent scientists.¹²⁹ The committee works with a National Research Council staff officer and a nonvoting scientist from each of the two sponsoring agencies. The heads of the two sponsoring agencies make the final choice of members, but from a pool recommended by the selection committee.¹³⁰ Thus, while policy makers ultimately chose the science board members, the involvement of outside scientists helps to ensure that the board's membership is drawn from credible scientists.

A further protection of the board's independence is its ability to influence its own work plan. The board will consider only those questions it finds to be amenable to scientific analysis, and it may undertake work on its own motion.¹³¹ The work plan must also take into account questions posed by the two sponsoring agencies, but questions cannot be dictated solely by the agencies.

When the board was first created, the independent selection committee suggested that members be drawn largely from the *Upstream* and *Return to the River* panels, ensuring that members included independent scientists who were already engaged in the Columbia River issues. The initial ISAB, then, represented not just a valuable pool of talent, but talent with a collective sense of what they were about. How well this shared perspective will carry beyond the initial membership remains to be seen.

The role of independent science expanded soon after the creation of the ISAB. *Return to the River* argues for independent scientific review of annual fish and wildlife funding decisions.¹³² The Bonneville Power Administration currently spends about \$100 million a year on habitat, artificial production, research, monitoring, and other measures to implement the Council program.¹³³ When Bonneville makes these funding decisions, it seeks recommendations from fish and wildlife managers and tribes, which in many cases stand to benefit from funding

128. See *Agreement Regarding the Independent Scientific Advisory Board*, *supra* note 124, at 2-3.

129. See *id.*

130. See *id.*

131. See *id.* at 4.

132. See *Return to the River*, *supra* note 11, at 44.

133. See *White Paper: What is BPA Spending for Fish and Wildlife?*, *supra* note 84.

awards.¹³⁴ *Return to the River* argues that these projects should also be subject to “credible scientific review.”¹³⁵

In 1996, Congress amended the Northwest Power Act to call for this review of funding decisions.¹³⁶ The 1996 amendments require the National Academy of Sciences to provide the Power Planning Council with nominations of scientists to constitute an “Independent Scientific Review Panel.” The review panel is charged with annually evaluating proposals for Bonneville funding to determine whether they (1) are consistent with the Council’s fish and wildlife program, (2) are based on “sound science principles,” (3) help fish and wildlife, and (4) have clearly defined objectives and monitoring and evaluation provisions.¹³⁷ The review panel submits its recommendations to the Council, which makes them available to the public for comment.¹³⁸ After hearing from the public, the Council makes final funding recommendations to Bonneville.¹³⁹ The Council is not bound by the science panel’s recommendations, and must consider additional factors, including cost-effectiveness and effects of ocean conditions. However, the Council must explain in writing if it does not accept any of the review panel’s recommendations. To promote consistency between the new science panel and the ISAB and to avoid a proliferation of scientific boards, the Council appointed the review panel largely from the ISAB’s membership.

The ISAB and the independent scientific review panel constitute a powerful new scientific influence in the Columbia River conservation effort. The two panels tend to bring a broad ecological perspective to their work, and there is little question that this perspective is changing the tenor of the Columbia River debate. The panels push policy toward an ecosystem model of species conservation at the programmatic level and in the arena of funding. They also can act as institutional advocates for scientific methods.

134. See H.R. Rep. No. 104-782, at 104 (1996).

135. *Return to the River*, *supra* note 11, at 44.

136. See Energy and Water Development Appropriations Act of 1997, Pub. L. No. 104-206, § 512 (1996) (amending § 4(h)(10) of the Northwest Power Act, 16 U.S.C.A. § 839b(h)(10) (West Supp. 1998)).

137. 16 U.S.C.A. § 839b(h)(10)(D)(iv) (West Supp. 1998).

138. See 16 U.S.C.A. § 839b(h)(10)(D)(v) (West Supp. 1998).

139. See 16 U.S.C.A. § 839b(h)(10)(D)(iv).

This infusion of independent science has also generated new issues and predictable friction. There is concern over the fact that only the federal government (through the Fisheries Service) and the states (through the Power Planning Council) formally interact with the science boards while Indian tribes do not.¹⁴⁰ The tribes play key roles in Columbia River fish and wildlife policy, and in other aspects of the Columbia River governance debate their involvement is deemed essential.¹⁴¹ While the Council and the Fisheries Service want to address this problem, it is easier to describe than it is to solve.¹⁴² Knowing that independent science boards are likely to say inconvenient things, tribes have to ask themselves whether they want to join in sponsoring the boards, or whether they are better off maintaining their distance from a process they cannot control. Tribes also have difficulty designating someone to represent all thirteen tribes jointly in these matters. Yet the lack of tribal participation has real disadvantages. Unless they can find an effective means of participation, the tribes lack influence in a vital area. Conversely, the Fisheries Service and the Council will feed the tribes' mistrust unless they can offer the tribes a meaningful opportunity to join in co-sponsoring the science boards.¹⁴³

A different source of concern arises from a growing load of scientific review assignments that stem from congressional requests for help in sorting out other tangled issues. In 1997 and 1998, the requests involved artificial production programs and several additional federal budget categories.¹⁴⁴ These matters require congressional appropriations and

140. See Letter from John Etchart to William Stelle, Jr., Regional Director, National Marine Fisheries Serv. (Dec. 14, 1998).

141. See, e.g., *Memorandum of Agreement for the Columbia Basin Forum*, signed by several Northwest states, federal agencies, and tribes on January 29, 1999.

142. See *id.*

143. Four tribes sued the Council for funding decisions arising from the recommendations of the first independent scientific review in 1997. See *Petition for Review Under the Northwest Power Act, Nez Perce Tribe v. Northwest Power Planning Council* (9th Cir. 1998) (No. 97-71267); *Petition for Review Under the Northwest Power Act, Confederated Tribes of the Warm Springs Reservation v. Northwest Power Planning Council* (9th Cir. 1998) (No. 97-71268); *Petition for Review Under the Northwest Power Act, Confederated Tribes & Bands of the Yakima Indian Nation v. Northwest Power Planning Council* (9th Cir. 1998) (No. 97-71269); *Petition for Review Under the Northwest Power Act, Confederated Tribes of the Umatilla Indian Reservation v. Northwest Power Planning Council* (9th Cir. 1998) (No. 97-71267).

144. See Committee on Appropriations, *Report on Energy and Water Development Appropriations Bill, 1998*, S. Rep. No. 105-44, at 117-18 (1997) (artificial production review) (conference report to accompany S. 1004) [hereinafter S. Rep. 105-44]; *Making Appropriations for Energy and Water Development for the Fiscal Year Ending September 30, 1998 and for Other*

raise some of the same issues that are involved in the basin's annual funding reviews.¹⁴⁵ These expanded reviews make perfect sense, enlarging the scope of scientific review and closely aligning regional and congressional funding. But the limited membership of the scientific boards is stretched thin with the growing work.

There is also concern that proliferating scientific reviews reflect expectations that are unlikely to be met. Policy makers want to know whether proposed initiatives will work. Reports like *Return to the River* offer useful critiques of policy, but may imply that an omniscient science is ready to prescribe the *real* solutions. However, science often uncovers deeper mysteries rather than solutions, so scientists tend to give qualified, probabilistic responses, or answers that do not satisfy the political impulses that prompted the original question.

For example, one of the contentious questions in the Columbia region concerns funding for structural improvements to protect fish trying to pass dams. These are big-ticket investments—bypass systems, surface skimmers, and other big, complex technologies—and different strategies are being implemented at different dams because each dam poses unique problems. In making appropriations, Congress is faced with doling out limited funds, and regional interests routinely disagree over what type of improvement is suitable at a given dam and which improvements are more important than others. Each party brings its own scientific arguments and Congress, understandably, looks for qualified authorities to sort out the claims. More than that, Congress wants to know that these improvements make sense in the big picture. Congress wants to know the overall strategy at which these multiple paths are aimed. These concerns prompted Congress to ask the Northwest Power Planning Council and the independent scientific advisory board to review major fish mitigation capital construction activities.¹⁴⁶

In a recent report responding to Congress's request, the ISAB suggested that structural improvements at dams should be evaluated in light of a test of biological effectiveness that evaluates the extent to

Purposes, H.R. Rep. No. 105-271, at 29 (1997) (capital review) (conference report to accompany H.R. 2203) [hereinafter H.R. Rep. 105-271].

145. See S. Rep. 105-44, *supra* note 144, at 117-18; H.R. Rep. 105-271, *supra* note 144, at 29.

146. "The conference agreement includes \$95,000,000 for the Columbia River Juvenile Fish Mitigation program in Washington, Oregon, and Idaho instead of \$85,000,000 as proposed by the House and \$117,000,000 as proposed by the Senate. The conferees note that the budget request for this program appeared to reflect the pursuit of multiple restoration strategies. Some of these may not be adopted, rendering expensive measures obsolete." H.R. Rep. 105-271, *supra* note 144, at 29.

which improvements enhance “conditions essential to the life history of the species.”¹⁴⁷ The ISAB said that while this test should drive decisions on dam improvements, it rarely did.¹⁴⁸ At the same time, according to the ISAB, some of the multiple strategies that are working the best on the river were arrived at not through design, but by observation and trial and error.¹⁴⁹ An ice and trash sluiceway that was not intended for fish passage turns out to be more effective than many systems designed for fish passage.¹⁵⁰ One of the more promising technologies—surface bypass—is modeled on a hydrocombine at Wells Dam that was not designed for its fish passage qualities.¹⁵¹ The fact that Basin conservation efforts have not settled on a single, standardized technology, but have implemented whatever works, has led to broader protection of more diverse populations.¹⁵² In a sense, the ISAB can be read as an endorsement of a skeptical, empirical approach to the problem of dam modifications.

The science board’s response makes good sense from an ecological perspective. It reflects the principles of *Upstream* and *Return to the River* and underscores the theme of managing for uncertainty. However, for those looking for consensus on a logical funding path and a way to avoid false starts and minimize redundancy, the report offers something quite different. It points to the need to continue experimentation with diverse methods, to protect more populations, to anticipate that some efforts will fail, and to anticipate the usual disorder that characterizes humans groping for solutions.

These communications between scientists and policy makers can frustrate both sides. Policy makers may not get the answers they expect, and scientists may put energy into answers that they come to feel are discarded for political reasons. In the end, however, the relationship will persist because it has to persist. Conservation policy cannot be effective if it lacks scientific strength, and scientific advice cannot be meaningful if it has no purchase in policy arenas. This mutuality does not disappear

147. Independent Scientific Advisory Bd. et al., *ISAB Rep. 99-4, Review of the U.S. Army Corps of Engineers’ Capital Construction Program* pt. III at 13 (1999).

148. *See id.* at 4–5.

149. *See* Northwest Power Planning Council, *Review of the Corps of Engineers’ Columbia River Fish Migration Program* 10–11 (1999).

150. *See id.*

151. *See id.*

152. *See id.*

in the wake of frustrations, as difficult as the blunt talk that passes back and forth may be.

At the same time, it bears emphasis that joint science boards do not dispel the uncertainties that surround species conservation issues. They necessarily leave the onus of judgment on political institutions, which is appropriate. On major resource issues, even the best scientists deal more with hypothesis than fact. Because of this, the basic caution of adaptive management to anticipate surprise is equally applicable to the advice of science boards. Contemporary scientists may have a vision that offers important clues to species recovery. But ten or twenty years from now we will know more and our vision will be different. Skepticism is therefore equally applicable to the advice of science boards, and the boards themselves should be guarantors that their assumptions will be ruthlessly tested.

4. *Ecosystem Policy and the Framework Project*

The authors of *Return to the River* and other reviewing scientists report that evaluation of the Columbia River conservation program is almost impossible because these efforts have no coherent conceptual foundation, only a collection of different management objectives and scientific assumptions.¹⁵³ One of the first indications of this problem emerged in the late 1980s, when the Northwest Power Planning Council asked a panel of independent scientists how the Council could evaluate progress under the Council's fish and wildlife program. The scientists' response was, in effect: "Progress toward what?" To the scientists, the Council's program looked like a miscellaneous collection of recovery and mitigation measures, each with different scientific assumptions and management objectives.¹⁵⁴ To a certain extent, this problem is rooted in the Northwest Power Act, which requires the Council's fish and wildlife program to be based on the recommendations of fish and wildlife managers. But whatever the source of the problem, the independent scientists maintained that the program could not be evaluated unless it was based on an explicit, integrating framework—a system of goals, objectives, and scientific logic to link aims and actions.¹⁵⁵

153. See Bonneville Power Admin. Scientific Review Group, *Critical Uncertainties in the Fish and Wildlife Program* 13–14 (1993).

154. See *id.*

155. See *id.*

The Columbia Basin has made relatively good progress in collecting and systematizing data,¹⁵⁶ but much less progress in establishing benchmarks to measure progress for fish and wildlife policy. There are many practical reasons for the problem. The river has always been pulled in many different directions at once.¹⁵⁷ Historically, there has been only episodic agreement on priorities, and the river has many different forums in which policies are weighed using different scales of value.¹⁵⁸ The lack of incentives for self-evaluation in fish and wildlife policy and the absence of an institution with the political or legal muscle to hold management programs to account have made it difficult to evaluate progress.¹⁵⁹ But the problem is not just practical, it is also conceptual. Although no one disagrees that effects in one part of the ecosystem cannot be understood in isolation from the rest of the system, there is no overall framework in which to connect the parts. Without understanding how these connections work in the aggregate, it is difficult to organize or evaluate a large recovery program.

Return to the River addresses the lack of a conceptual foundation and offers a three-part conceptual foundation for fish and wildlife policy in the Columbia region. First, *Return to the River* says that it is a mistake to think about fish and wildlife in pieces.¹⁶⁰ There are no individual habitat, hydropower, hatchery, and harvest problems. Salmon populate ecosystems that include rivers, estuaries, and an ocean, which are interdependent.¹⁶¹ More than that, salmon ecosystems are populated by a large variety of organisms that need to be present if salmon are going to be healthy.¹⁶² Second, strong fish and wildlife populations need many

156. An aquatic resource information center called StreamNet, funded with federal hydropower revenues, has gathered and made accessible an immense body of data on fish and wildlife abundance and distribution and on an array of habitat, harvest, and mitigation efforts. See The Northwest Info. Network (last modified July 12, 1999) <<http://www.streamnet.org>>. See also, e.g., Duane Anderson et al., *Report on the Status of Salmon and Steelhead in the Columbia River Basin—1995* (last modified April 1996) <<http://www.streamnet.org/Reports/crstat95.htm>> (reporting on status of Columbia River salmon runs).

157. See generally John M. Volkman, *A River in Common: The Columbia River, the Salmon Ecosystem, and Water Policy* (1997).

158. See John M. Volkman, *The Law of the Columbia River, in Competing for the Mighty Columbia—Past, Present and Future: The Role of Interstate Allocation* 22–23 (1998).

159. See Volkman & McConnaha, *supra* note 79, at 1261, 1271.

160. See *Return to the River*, *supra* note 11, at 18.

161. See *id.* at 20–25.

162. See *id.* at 20–21; Independent Scientific Group, *Return to the River: An Ecological Vision for the Recovery of the Columbia River Salmon*, 28 *Envtl. L.* 503, 509 (1998).

healthy habitats that are linked rather than isolated.¹⁶³ Without connected habitats, salmon lack the spawning areas, migration conditions, and food webs they need. Third, the structure of fish and wildlife populations needs to guide recovery policy. In particular, diverse life histories,¹⁶⁴ genetic diversity, and metapopulation organization are crucial ways in which salmon adapt to their environment.¹⁶⁵ Unless fish and wildlife recovery builds from these foundations, the report implied, wild salmon and other species would not persist over the long term.¹⁶⁶ Scientific questions can be asked about this vision, but the harder problem is political. What does a large basin filled with contending parties and agencies do with such a vision? How do disparate entities find consensus on something as broad as an ecological vision?

To address the need for an explicit vision for the Columbia River conservation effort, federal, state, and tribal governments together have formed a process called the Framework Project.¹⁶⁷ The project aims to involve policy makers, scientists, and other parties in articulating and analyzing alternative visions using an explicit set of ecological assumptions, theories, and principles. The resulting analysis is intended to provide a common frame of reference for a spectrum of decisions, including federal agency decisions, the Northwest Power Planning Council's decisions, and others. The project participants implicitly acknowledge that a framework requires a balance between policy and science. An integrated program for the Columbia River and its species can emerge only from policy judgments representing both a social and a scientific vision of the river's ecological, cultural, and economic functions.¹⁶⁸ The ecological element is supplied by a scientific foundation that is drawn largely from *Upstream, Return to the River*, and the scientific work of the Interior Columbia Basin Ecosystem Management Project.¹⁶⁹ This foundation provides a logical sequence for evaluating the

163. See *Return to the River*, *supra* note 11, at 22–23.

164. A life history is an expression of the time a young salmon emerges from its egg, begins to migrate downstream, returns to spawn, and other characteristics.

165. See *Return to the River*, *supra* note 11, at xvi–xvii.

166. See *id.* at 33.

167. See Multi-Species Framework, *Columbia River Basin Multi-Species Framework: Helping Define the Future of the Columbia River 1* [hereinafter *Helping Define the Future*].

168. See *id.*

169. See *Integrated Scientific Assessment for Ecosystem Management in the Interior Columbia Basin, and Portions of the Klamath and Great Basins* (Thomas M. Quigly et al. eds., 1996) (prepared as part of Interior Columbia Basin Ecosystem Management Project).

ecological implications of different courses of action.¹⁷⁰ Social, political, and other considerations are supplied by a group of government entities and stakeholders who identify alternative fish and wildlife management approaches that are more or less protective of other interests in the river.¹⁷¹ Project analysts evaluate these policy alternatives in light of the scientific foundation. The process is recursive: a first round of analysis goes back to the policy group, that group revises the alternatives in response to the analysis, and the alternatives then go back to the analysts for further evaluation.¹⁷² The final analysis will inform federal, regional, and other decisions regarding Columbia River policy.¹⁷³ Ideally, the analysis will give the parties glimpses of a broad, long-term vision for the river, a chance to consider the overlapping needs of many species, and a way to assess ecological and human stakes over the long term. How far the framework process actually moves the Columbia debate remains to be seen. But even if the project does not lead the contending parties to a single vision, it will have begun to shift the parties' thinking toward a broader ecosystem whose parts connect.

C. Adaptive Management and the Continuing Dialogue Between Scientists, Policy Makers, and the Governed

In developed ecosystems, policy makers will always face complex decisions involving human factors that are legally protected, as well as ecology, economics, politics, and ethics. Policy makers need scientific information to make these decisions, but science does not dictate the ultimate judgments.¹⁷⁴

The Framework Project, PATH, and other methods in the Columbia River effort illustrate the interactions that need to occur between policy makers and scientists to make sensible species conservation policy. Only through such interactions can we decide how far the Basin should move from technological methods to more natural, "normative" conditions. Even if there were consensus that moving *toward* a river with more ecological function is desirable, broader judgments will need to be made

170. See Ecological Work Group, *An Ecological Framework for the Multi-Species Planning Process* (1998).

171. See *Helping Define the Future*, *supra* note 167, at 1-2.

172. See *id.* at 2.

173. See *id.* at 3.

174. See William Stelle, Jr., *Overcoming the Seven Myths of Columbia River Salmon Recovery*, 28 *Env'tl. L.* 493, 499 (1998).

about the habitats that we should restore and reconnect, the technologies that we should discard or keep, and who should pay for the effort.

Scientific insights will shape these decisions, especially insights into the population structure of key species. For example, the metapopulation concept of *Upstream and Return to the River* contemplates the Hanford Reach fall chinook population as being the seed for an enlarged core population, connecting with tributary populations like those in the Yakima, Umatilla, and John Day Rivers. But the policy issues implicit in this idea are significant. Are fall chinook, with their associated species communities and ecological processes, the right focus for conservation planning? If so, are we willing to lower the levels of reservoirs adjacent to the Hanford Reach or even remove some of those projects? How would we address their important role in the energy system and the complications that lower reservoirs might create for navigation? What of the lower reaches of the Yakima, Umatilla, and John Day Rivers and other major tributaries? Would human uses change there to accommodate ecological rehabilitation? How far are we willing to go to test these ideas? Would we be better off to leave the river largely as it is, forget the idea of expanding core populations, and run ecological risks with tributary populations, expanded hatchery programs, and other technologies? While all of these are policy judgments, they will stand up only if scientific knowledge infuses them and the best scientific methods test them.

A central assumption in the Columbia River effort is the idea that adaptive management can structure the dialogue between policy and science. Yet, it is hard to quarrel with Carl Walter's observation that "[e]xperimental management planning has floundered in complex institutional settings like the . . . Columbia River."¹⁷⁵ This is not to say that experimental management is a failed enterprise in the Columbia Region. Adaptive management has spurred the development of learning tools because it draws attention to what we do not know and raises questions about how we can find out. Posing these awkward questions in the Columbia River effort, adaptive management has shaped policy by generating initiatives in applied research, collaborative modeling, independent scientific advice, and ecological synthesis. However, the Columbia River effort has not demonstrated a willingness or ability to use large-scale experiments systematically to probe uncertainties. The

175. Walters, *supra* note 83, at 12.

potential human effects of experimentation have limited the learning in the Columbia to smaller, less risky, and less-penetrating exercises.

There are benefits to the Columbia River effort's diverse and less-organized collection of learning tools. When no one has all the answers, large management experiments may simply be too risky. Investigating problems in different ways from several directions may be a better way to test diverse and obscure ecological problems. While they may be unable to manage large experiments, communities with limited resources that are dealing with emerging conservation problems may find that a variety of learning tools is more useful. They can compensate for the limitations of these smaller tools by tapping into existing efforts, such as the independent science boards like ISAB, large-scale scientific syntheses like *Upstream* and *Return to the River*, and extensive collaborative modeling processes like PATH. These existing efforts will also lead communities toward broader ecological considerations. If established on sound foundations, smaller, varied learning tools can lay the groundwork for disparate parties to collaborate.

But without systematic experimentation, these learning tools may come up short. In an ecosystem like the Columbia River, scientists have to make sense of the critical variables in a sprawling ecosystem. By aiming at narrower phenomena, we may attribute problems to the wrong causes, or focus too much attention in some areas and not enough in others. There is always the risk that fish and wildlife populations will die off before we find answers. Developing more powerful, penetrating ways to experiment with ecosystems is a puzzle the Columbia effort has yet to solve.

Finding these solutions may hinge less on scientific insight and clear-headed government institutions than on social will. The difficult equation underlying species conservation policy is the potential sacrifice humans may have to make for ecosystem recovery. This equation is not one governments alone can solve. Even if contending government institutions see ways to conserve species, many critical parts of the ecosystem are privately owned. In a system of government premised on consent of the governed, the divisiveness of species conservation issues can paralyze political discourse and stall experimentation.

These divisions are not impossible to bridge. The harsh specter of species extinctions and deepening policy stalemate will take a mounting toll that few people will willingly pay. Most people will concede that a river mired in long-term conflict over vanishing species is not what they want to leave to their grandchildren. Faced with this prospect, even people who disagree over species conservation issues in the short term

may find it possible to see a common future in the long term. Science is giving Columbia River parties a glimpse of roads they could follow. Getting from here to there will involve experimentation with tools very like those of adaptive management.

IV. CONCLUSION

If communities are to create viable species conservation programs, they must appreciate the extent to which uncertainty determines what can be achieved. The Columbia River conservation efforts teach important lessons in managing uncertainty, and provide learning tools that other communities can use as they address species conservation issues. The impulse to learn remains one of the most compelling aspects of Columbia River conservation policy.

From the point of view of those interested in a vibrant federalism, it is particularly important that the relationship between scientists, policy makers, and communities work. If the Federal government, states, tribes, and other parties share common scientific assumptions, they can defuse misunderstandings that would otherwise undermine progress in conservation. Endangered Species Act listings, in particular, put powerful levers of resource policy in federal hands, and may threaten to eclipse regional, state, and tribal policy. The resulting tensions are politically combustible and can consume contending jurisdictions and other parties in arguments that sap political energy and leave scars. By developing a joint understanding among federal, state, tribal, and local interests, science can help create a common language for collaboration.

Finally, the Columbia River efforts demonstrate this: decisions about species conservation in developed ecosystems are ultimately exercises in cultural evolution.¹⁷⁶ We are slowly learning how to understand our effects on the world and considering whether to change our behavior to sustain the environment on which we have depended. Evolution of this kind is inevitably fitful and our hesitant attempts at experimentation may seem feeble. But whether we continue to learn and adapt may determine our own success as a species.

176. See McEvoy, *supra* note 66, at 16.