Restoration of Pacific Salmon: the Role of Science and Scientists

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RESTORATION OF PACIFIC SALMON: THE ROLE OF SCIENCE AND SCIENTISTS[1]

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Abstract. *Many Pacific salmon "stocks" have declined and a significant, but unknown, number have been extirpated. How to solve the salmon "problem" is one of the most vexing public policy challenges in natural resource management. Even with complete scientific knowledge — and scientific knowledge is far from complete or certain — it would be a challenging policy problem.*

The salmon decline issue is often defined as a watershed alteration policy problem, in part because changes in watersheds are highly visible and often occur on public lands where individuals and organizations have direct input to decision making. The more difficult — and critical — part of the debate deals with policies and decisions affecting private rural enterprises (especially farming and logging); industry; electricity generation; national defense; urban development; transportation; competing personal rights and freedoms; the prerogatives and roles of local, state, and federal government and Indian tribes; and policies on human population level, reproduction, emigration, and immigration.

The salmon problem illustrates a class of policy issues that are socially wrenching and are becoming increasingly common in the western United States as demands increase for limited resources. Technocrats, scientists, biological resource managers, and scientific advisors should avoid advocating political choices driven by personal interest and packaged under the guise of a scientific imperative. However, it is equally important not to permit tough policy choices to masquerade behind the cloak of scientific imperative — a prostitution of science and scientists that sometimes provides a convenient cover for avoiding difficult social choices. The complete implications of each alternative public choice should be fully and clearly explained, including the short- and long-term consequences, and especially the level of scientific uncertainty.

Key words: salmon management, fisheries management, policy analysis, ecosystem health, socioeconomic issues

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INTRODUCTION

How to evaluate "solutions" to the Pacific Northwest salmon "problem" is one of the most vexing challenges in ecological policy analysis. All "solutions" require major economic, social, and personal costs, so scientific information is viewed as essential in policy analysis — and scientists are essential participants. Scientists have a role in the debate; however, that role is constrained by the limits of the scientific method and the practice of science generally.

That's the take-home message for my talk. But first, let me move back to the beginning and start with what I have called the salmon "problem." There are entire books (National Research Council 1996; Ridlington and Cone 1996; Stouder *et al.* 1996) that synthesize what we know about the decline of Pacific salmon, so I will merely touch on a few of the main points.

Many Pacific salmon "stocks" (a term used in fisheries management for a group of interbreeding individuals that is roughly equivalent to "population") have declined and a significant, but unknown, number no longer exist. Over 200 stocks are classified as "at risk" (Nehlsen *et al.* 1991; Nehlsen 1996) in California, Oregon, Washington, and Idaho. There is uncertainty over the historical number of stocks (perhaps 1,000 to 2,000), the status of individual stocks, and the causes of the decline of specific stocks, but the general conclusion is clear: There *is* a widespread decline of salmon from southern British Columbia southward.

California, Oregon, Washington, and Idaho represent the southern range of the geographic distribution of Pacific salmon in North America and the location where the decline is most acute. In contrast, Alaska's salmon stocks appear to be thriving and support record catches. Further, the aquaculture industry (especially from Europe and South America) can spawn and raise salmon in captivity, produce a quality product, and sell it cheaper than most wild salmon caught in the Pacific Northwest. Thus, despite the decline of salmon stocks in the Pacific Northwest, salmon have never been more abundant in the retail market because of supplies from aquaculture and Alaskan fisheries. In short, no *species* of salmon is in danger of near-term extinction, even though many individual stocks are declining or have been extirpated (Lackey 1996a; Lichatowich 1996; Nehlsen 1996; Nehlsen *et al.* 1991).

Lately, it has become common to debate the Pacific salmon problem by focusing on the upper portions of watersheds, especially forest and range lands. What happens on forest and range lands is important for salmon, but it may be the easiest part of the problem to address politically because much of this land is publicly owned. A more difficult — and critical — part of the debate deals with policies and decisions impacting private rural enterprises (especially farming and logging); industry; electricity generation (including hydro, fossil fuel, and nuclear); national defense; urban development; transportation (including road, rail, air, and water); competing personal rights and freedoms; the prerogatives and roles of local, state, and federal government and Indian tribes; and policies on human population level, including reproduction, emigration, and immigration. Overriding all policy aspects of the salmon problem is that over the past 100 to 150 centuries, the three Pacific coast states have changed from a relatively uninhabited region to one supporting 50 million people, most of whom live in urban areas.

LIFE HISTORY

There are seven species of Pacific salmon and several species of sea run (anadromous) trout. These species are currently classified as members of genus *Oncorhynchus* by the American Fisheries Society. Five of the seven species of Pacific salmon — *chinook, coho, chum, sockeye, and pink* — are found on both sides of the Pacific; two, the *masu* and *amago*, are found only on the Asian side. Of the sea run trout, *steelhead* and *sea run cutthroat* are the most widespread and share many life history characteristics with Pacific salmon. All spawn in freshwater (rivers, streams, or lakes, and certain species occasionally intertidally), spend various lengths of time in freshwater, migrate to the ocean, and spend from one to several years at sea. Depending on the species, salmon and trout from the Pacific Northwest travel along the coast of North America or make a major migration past the Aleutian Islands. Salmon and trout typically return to their stream of origin to spawn. Salmon die after spawning, whereas trout may not. Ocean conditions (especially El Nino events) have a major influence, which can be either positive or negative, on the size of a particular "year class." Adverse ocean conditions (for salmon originating from Washington, Oregon, Idaho, and California) have existed for the past two decades (Pearcy 1996).

Historical Run Extent & Sizes

The extent and size of historical salmon runs is an important piece of information in policy analysis. There is a natural tendency to use the 1800s as the baseline, understandable because European settlers reported massive salmon runs. However, the size of salmon stocks varied tremendously over the past 10,000 years (Chatters 1996). At the end of the last Ice Age, 10,000 - 15,000 years ago, humans and salmon expanded into the Pacific Northwest (Pielou 1991). Until 7,000 to 10,000 years ago, much of the upper reaches of rivers were blocked by glacial ice. Eroding glacial deposits and low water flows limited the size of the salmon stocks for the next several thousand years.

Conditions improved for salmon approximately 4,000 years ago, probably in part due to improved oceanic conditions (Chatters 1996). Human use of salmon increased dramatically, eventually affecting run size in some rivers, especially toward the southern part of the distribution. Salmon runs fluctuated greatly, but the long-term trend was upward and the runs reached their highest levels in the past few centuries. From the early 1500s through the 1800s, a series of epidemics decimated aboriginal human populations (Dobyns 1983); population reduction thereby causing a decline in fishing pressure. Concurrently, climatic conditions in the southern part of the range became more favorable for salmon. The high levels of salmon in the early to mid-1800s were thus due to a long-term trend toward generally more favorable oceanic conditions (for salmon), improved continental climatic conditions (for salmon), and a dramatic decrease in aboriginal fishing pressure.

Aboriginal Fishing

The early aboriginal immigrants gradually developed societies dependent on the annual return of salmon. For the past 3,000 - 5,000 years, there was a rough equilibrium between salmon and human populations because the number of salmon that could be harvested was limited by lack of efficient (at least in most locations) fishing gear; inability to preserve, store, and distribute the catch on a large scale; and foremost, a relatively stable human population in the range of a million. Aboriginal fishing may have had significant effects on individual stocks, especially those in smaller rivers and streams which are more vulnerable to the effects of fishing.

Fishing Pressures

Conditions changed markedly in the nineteenth century (Chapman 1986). The first half of the century saw a sudden, additional *decrease* in human population in the Pacific Northwest due to introduced diseases. Climatic conditions for salmon were favorable and salmon stocks likely reached historic highs. However, starting in the middle to late 1800s, the human population *grew* rapidly due to major immigration from eastern North America. This growth coincided with the advent of more efficient fishing gear and the ability to preserve and distribute the catch in cans. The effect on many salmon stocks was massive and rapid. Within six or seven decades many stocks were reduced below levels required to support fishing; some were probably extirpated (Lichatowich 1996). Competition for salmon harvest continued to be severe; recreational, commercial, and Indian fishermen demand a portion of a dwindling catch, politically pressuring fisheries managers to maintain high catch levels.

Other Factors for Decline

There were many other causes for the decline of salmon besides overfishing. Since most of the Pacific Northwest is arid, irrigation is necessary for farming. Water diversions for irrigation, coupled with increased use of pesticides and herbicides, have contributed to reductions in salmon runs. Since the area's timber is of high commercial quality, the harvest and transport (via water) of timber has also had adverse effects on salmon spawning and rearing. Floods historically have been common and devastating, at least from the perspective of most people; therefore flood control has been a societal priority for many years. Dams impede fish passage — both for returning spawners and especially for migrating young fish — and hydropower operations have long been a challenge to fisheries managers. Dams also greatly alter water flow and sediment transport in watersheds, causing a number of ecological changes.

Hatchery Stock Impacts

Fisheries management has historically focused on hatcheries to mitigate changes made in the freshwater environment. There have been some successes, but some hatchery programs used to enhance recovery of salmon stocks may have actually accelerated declines (Lichatowich 1996). Pacific salmon can be easily spawned and raised under artificial conditions. Since the late 1800s, when hatcheries first were used to help enhance salmon stocks, attitudes have evolved from near universal support to widespread skepticism of enhancement. Many individuals are now openly hostile to the use of hatcheries, contending that the 90 hatcheries releasing salmon into the Columbia River system actually worsen conditions for naturally spawning salmon (Wright 1993).

Hatchery-produced fish may introduce diseases, compete with naturally spawned fish, and alter genetic diversity. The decline of wild stocks is often masked by the presence of hatchery-bred salmon, a situation that takes place even in the presence of near pristine habitat. Once released, hatchery-produced fish mix with naturally spawned fish, resulting in simultaneous harvest of abundant hatchery fish and less common wild fish. There is no way to permit fishing for hatchery fish and protect wild fish.

Exotic Species Impacts

Other factors have complicated the salmon problem. One especially troublesome development (from a salmon perspective) has been the introduction of non-native species such as walleye, striped bass, shad, brown trout, brook trout, smallmouth and largemouth bass, bluegill, northern pike, crappie, catfish, and carp. As salmon stocks declined and habitats were altered, other fishes, often exotic, became established and prospered. Once these populations, especially the exotics, are established, it is extremely difficult for salmon to reestablish viable stocks against such formidable competition and predation, coupled with an altered habitat no longer favorable to salmon (Lackey 1996b).

Oceanic Factors

But to understand the salmon "problem", we must also look at the oceanic portion of their life-cycle. Most salmon spend much of their life in salt-, not freshwater. Oceanic factors play an important role in salmon production on both sides of the North Pacific Ocean (Pearcy 1996). For example, the long-term pattern of the Aleutian low-pressure system corresponds with trends in salmon catch. On shorter time scales, El Nino events have a definite effect on salmon stocks. It is difficult, and probably impossible, to determine whether changes in the condition of salmon stocks are due *primarily* to oceanic factors, land-based factors, or natural variation in stock size. Yet, oceanic *and* freshwater conditions affect salmon stocks substantially (Francis 1996).

Climatic Change

Climatic change also affects the condition of salmon stocks. As with the ocean, the type and degree of effect are rarely clear (Francis 1996). Recent examples of climatic change in the Pacific Northwest are the severe winters of the 1880s when most range cattle were killed, the extreme droughts of the 1910s and 1930s when many farmers were driven off arid lands, and the general drought of the 1970s and 1980s when water use conflicts were exacerbated. If future climatic change (natural or human induced) causes the region to change even more, then additional sections of the current range of Pacific salmon will be occupied by fishes better adapted to these altered habitats.

CHOICES

OK, we have covered the biology of the salmon "problem" — now let's look at the problem from a policy perspective. On the simplest level, salmon stocks are declining and the "public" wants action. However, as a public policy issue, the question is more correctly addressed as a *choice* among competing alternative solutions (Smith and Steel, 1996). Couldn't the policy "problem" be equally formulated in terms of protecting agriculture? Or, maintaining the availability of inexpensive (and subsidized) electricity? Even if we decide that the problem ought to be defined in "fish" terms, are we primarily interested in preserving all stocks, or just the most important stocks? From an evolutionary perspective, is it even possible to identify the most "important" stocks? Or, are we interested in maintaining relatively high stock levels so that they are *fishable*?

Such questions are not unusual in public debates and public choice, but they illustrate that the need for specific scientific information depends on how the policy question is formulated (Lackey 1979). There are different information needs if the salmon policy problem is defined as fundamentally one of loss of biological diversity, maintaining "fishable" populations, or any of the other societal uses of water.

Choices in the debate are political. Does society define the salmon problem as a local, regional, national, or international issue? Benefits and costs are distributed very differently, depending on the geographical context. For example, if the salmon decline issue is viewed in a national context, benefits of maintaining salmon runs will be "shared" throughout the nation, although the costs (higher electricity rates, fewer agricultural jobs, less commercial development, etc.) will be largely borne locally and regionally. Therefore, whether the salmon problem is viewed as a local or regional problem, or a national one, is a crucial societal decision.

Nothing is free when resolving contentious issues in a democracy, and the salmon problem is no exception. For every benefit, there is a cost or at least a risk. Costs, of course, are only partially measured in monetary terms. Other, often more important, costs might be loss of personal freedom and civil or cultural rights, including property and fishing rights. Many of the options revolve around decisions about the relative importance of an individual's benefits and rights compared with societal benefits. Further complicating policy analysis is the fact that there are multiple costs — and benefits — with each alternative decision. Depending on one's values and political perspective, the terms "good" and "bad" can apply to very different people and institutions (Lackey 1994).

However, there is not an unlimited number of policy choices. In part, this is because there are options that are just not technically possible to implement, or would be extremely costly to implement. Here is where scientific information and scientists can play a useful role.

SCIENCE

Natural resource scientists in general, and fisheries scientists in particular, tend to focus on immediate stressors rather than on the socioeconomic decisions that can drive declines in salmon stocks. For example, it is much easier to study the effect of different widths of stream-side buffers than to evaluate the effects of a particular public forest policy or subsidized irrigation on salmon stocks. There are practical reasons why scientists reduce research problems to such narrow, technical levels. A reductionist approach tends to focus on what is tractable scientifically, but often overlooks the scientific information that is really important in policy analysis. Narrow technical questions are amenable to the traditional hypothesis testing approach traditionally favored in science, but reflect an implicit view of ecosystems as machines that can be reduced to their individual parts (Hughes 1996).

Classical use of hypothesis testing to better manage ecological resources requires that *treatments* be manipulated; i.e., dams, dam operation, flow diversions, agricultural runoff, and predation by marine mammals. However, such treatments can only be manipulated over a narrow range of alternatives. After all, would society allow for the elimination of agriculture in the Columbia Basin or the California's Central Valley to test the effects of agriculture on salmon? Would fisheries managers close all harvest activities or mothball all hatchery operations? So much for classical hypothesis testing.

"Health"

One increasingly popular approach in describing "scientifically" the salmon problem is to invoke the concept of "health." *Health* is a word that changes meaning to fit the surrounding context. It is also a word increasingly used to describe ecological resources (or ecosystems) in some ways divergent from those applied to individuals. None-the-less, the concept of "health" applied to ecological systems has a common-sense appeal, and many have struggled to rationalize the application of "health" to ecological systems (Rapport 1995; Lackey 1996a).

Everyone wishes to preserve his health which helps explain the appeal of the metaphor of ecological or ecosystem health. Some argue that the metaphor is wrong or, at best, of limited utility (Calow 1995). Among the typical arguments against using the health metaphor are (1) ecosystems are not organisms and do not behave like organisms (after all, organisms die and decompose but ecosystems do not), (2) there are no widely accepted indices of ecosystem health nor is it likely that any will be accepted soon, (3) use of the term in political debates masks the value and priority judgments that were made, the crux of the political debate. Others argue in favor of the metaphor as a very useful tool to explain tradeoffs to the public (Rapport 1995).

By contrast, there is societal consensus, at least in a general sense, about whether an individual person, dog, or cow is "healthy." However, when the concept is applied to ecological systems, there is an implicit assumption that there is some ecological condition or state that is ***desired*** or ***preferred***. To be healthy is desirable; to be sick is not. The condition of salmon stocks is often described against the norm of a "healthy" stock. Further, the health of salmon stocks is often offered as a surrogate for the health of ecosystems (Lichatowich et al. 1995). Appealing as health might be for individual humans, there are serious problems in transferring the concept of human health to ecological resources and ecosystems. The word "health" carries so much valueladen meaning from everyday life that it is difficult to use it as a descriptor of ecosystems (Lackey 1996a).

The role of science in defining ecosystem or ecological health is contentious. To categorize something as "healthy" requires an implicit determination of the desired or preferred state. For example, to say that a watershed is ecologically healthy implies something good, something desired, something preferred to alternative states (Lele and Norgaard 1996). However, that same watershed might be pristine forest, highly productive pasture land, an intensively managed vineyard, or a city of ski condos populated by urban refugees. Which state of this watershed is healthiest? In a similar light, why should we define the policy problem as a *salmon* problem? Does that mean that we have tacitly placed salmon ahead of other aspects of our environment? Why not focus on the problem of enhancing inexpensive urban housing, maintaining the availability of cheap food, or minimizing flood risk? Using the "health" concept in ecosystem management may not clarify, but actually cloud the fundamental choices society must make.

AN APPROPRIATE ROLE

The salmon problem illustrates a class of socially wrenching policy issues that will become increasingly common. Examples are the human response to drought, limitations on property rights, abortion, and the rights of certain individuals vs. the rights of others. These issues share a number of general characteristics: (1) *complexity* — There is an almost unlimited set of alternatives and tradeoffs to present to officials or the public; (2) *polarization* — These issues tend to be extremely divisive because they represent a clash between competing values; (3) *winners and losers* — Some individuals and groups will benefit from each choice, while others will not, and the existence of such tradeoffs is well known to the general public; (4) *delayed consequences* — There is no immediate "fix," and the benefits, if any, of painful decisions are not obvious for many years; (5) *decision distortion* — These are not the kinds of problems that a democracy addresses smoothly because it is very easy for advocates to appeal to strongly held values; and (6) *ambiguous role of science* — Scientific information is important but usually not pivotal in the choice of an alternative when the choice is primarily driven by value (political) judgments.

It is easy to despair and conclude that it is impossible to make a choice, that conflicting societal priorities and technical limitations preclude any rational resolution. The fact is, choices are being made — even the "no action" option is a choice. They may not be the best choices (*best* being defined as the desires of the majority and the choices being without unexpected consequences), but choices are being made.

An informed public (and elected and appointed officials) is crucial to choosing the "best" solution to the salmon problem. It is not easy for the public, or anyone, to deal with the technical complexity of the salmon problem and similar complex ecological policy problems. The most critical role for scientists is to provide the citizenry with a basis for understanding the relative risks and benefits among the possible alternatives to solving the salmon problem. To be credible, this must be done without advocating any one alternative. This is not a comfortable role for some scientists who hold strong personal (political) views on how the problem should be solved. Some even argue that scientists have a right, even an obligation, to advocate policies as citizens in their areas of scientific expertise. I don't share this view.

Finally, those of us who are technocrats, scientists, biological resource managers, or scientific advisors should remain humble in our dealings with the public and elected officials and overcome the tendency to advocate *political* choices driven by strong personal interest and packaged under the guise of a scientific imperative. However, it is equally important not to permit tough policy choices to masquerade behind the cloak of scientific imperative — a prostitution of science and scientists that sometimes provides a convenient cover for avoiding difficult social choices. The complete implications of each alternative policy choice should be fully and clearly explained, including the short- and long-term consequences, and especially the level of scientific uncertainty.

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