Saving Wild Salmon:

A 165 Year Policy Conundrum

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Introduction

The striking decline of salmon runs in California, Oregon, Washington, and Idaho has been typical of those that have occurred elsewhere. In other regions of the world where salmon were once plentiful, increasing human numbers, their activities, and consequent alteration of the landscape coincided with decreasing salmon abundance. Thus, what is happening to wild salmon in California, Oregon, Washington, and Idaho is the latest example of a pattern that has played out numerous times in other regions of the world for salmon (Lackey et al 2006a) and other fish species (Limburg et al 2009, 2011).

Prior to the 1800s, large spawning migrations (runs) of Atlantic salmon were found in many coastal rivers of western Europe and eastern North America (Montgomery 2003, National Research Council 2004). By the middle to late 1800s, many of those runs were drastically reduced, concurrent with human population increase and economic development (Limburg and Waldman 2009). Overall, salmon runs continue to be much reduced on both sides of the Atlantic Ocean. The largest remaining Atlantic salmon runs, although diminished by historical standards, occur in eastern Canada, Iceland, Ireland, Scotland, and the northern rivers of Norway, Finland, and Russia, locations with relatively few people and limited human impact on the aquatic environment. Nevertheless, Atlantic salmon are readily available in the retail market because commercial aquaculture provides an ample and consistent supply.

As with Atlantic salmon, Pacific salmon (Chinook, coho, sockeye, chum, pink, and steelhead) were historically abundant across a large region (Augerot 2005). Nevertheless, Pacific salmon, found on both sides of the North Pacific, have also declined substantially from historical levels, although not as dramatically as Atlantic salmon (Nehlsen 1997). Hatchery production has been used to maintain most runs in southern portions of the range (*e.g.*, Japan, Korea, California, Oregon, and Washington). Today, in California, Oregon, Washington, and Idaho, runs that are sufficiently large to support commercial, recreational, and tribal fishing almost always comprise mainly hatchery produced salmon. Runs of wild salmon in the northern portions of the range (*e.g.*, Russian Far East, Alaska, Yukon, and northern British Columbia) are in better condition, though there are large hatchery programs in these regions as well (Nehlsen 1997). There are indications that salmon numbers are increasing in Arctic habitats, presumably due to an overall warming trend (Nielsen et al 2013).

The discoveries of gold in California (1848) and elsewhere later resulted in substantial adverse effects on many salmon runs (Lackey et al 2006c). Efforts to protect and restore salmon populations in California, Oregon, Washington, and Idaho began in the early 1850s and such efforts have been technically challenging, socially contentious, and politically painful (National Research Council 2012). Overall, past recovery efforts for wild salmon (in contrast to salmon bred and raised in hatcheries) have been largely unsuccessful (National Research Council 1996, 2012). Over many decades, thousands of scientists have been involved with salmon recovery efforts, but prospects for recovery of wild salmon remain elusive (Scarce 2000, National Research Council 2012). Of the nearly 1,400 distinct Pacific salmon populations that occurred prior to 1848 in California, Oregon, Washington, and Idaho, an estimated 29% have been extirpated (Gustafson et al 2007). The remaining populations of wild salmon are greatly reduced, usually at less than 5% of their historical levels (Schoonmaker et al 2003). Twenty-eight evolutionarily significant units (i.e., a group of salmon populations considered to be a "species" for purposes of regulatory protection) are formally listed as either threatened or endangered as mandated by the Endangered Species Act (ESA).

Salmon recovery efforts are costly, though deciding which specific expenses should be deemed recovery costs is complicated and the subject of debate. Just within the Columbia River Basin, for example, salmon recovery costs have totaled approximately $10 billion since 1978 (Northwest Power and Conservation Council 2013), though part of this estimate reflects lost electricity sales (i.e., "forgone revenue") when the hydropower system curbed generation to meet constraints imposed by salmon recovery requirements (e.g., passing water downstream, but bypassing turbines).

As a public policy case study, wild salmon recovery in California, Oregon, Washington, and Idaho is characterized by several apparent conundrums:

1. For well over a century, both scientists and the public have recognized the dramatic decline of wild salmon runs, but consensus remains elusive on a regional recovery policy that would actually work.

2. Billions of dollars have been spent to restore wild salmon, but their overall, long-term downward trajectory continues.

3. Many populations of wild salmon are listed as "threatened" or "endangered," yet wild salmon are available seasonally in grocery stores — and farm-raised fresh salmon are sold year around.

4. Thousands of scientists and other technological experts are employed to facilitate the recovery of wild salmon, but, over the long-term, salmon populations have rarely responded positively.

5. The various species of salmon are among the most thoroughly studied fishes in the world, but the failure of recovery efforts is often attributed to a lack of scientific information.

6. Polling data show that the public supports recovering wild salmon populations, but politicians and most people are reluctant to make specific policy choices that would plausibly recover wild salmon.

7. The ESA, arguably the most powerful of U.S. environmental laws, has been extensively used by some policy advocates to force imposition of Federal authority (i.e., ESA listing of various salmon species), but this approach has been insufficient to achieve salmon recovery.

8. The overarching goal of the ESA is to protect at-risk species and the habitat upon which they depend, but this law, counterintuitively, may impede recovery of wild salmon in watersheds where the chances of recovery are greatest.

9. To offset the effects on salmon runs of certain dams constructed for hydropower, irrigation, and other purposes, Federal, State, and Tribal governments are required to operate salmon hatchery programs to supplement runs to sustain fishing, but these programs may actually weaken *wild* salmon runs.

10. Federal and state agencies are mandated with protecting and restoring wild salmon runs, but they are also tasked with promoting harvest (i.e., fishing) which can work against recovery.

Scientists tend to depict the policy debate as a scientific or ecological challenge and the "solutions" they offer are usually focused on aspects of salmon ecology (Naiman et al 2012). There is an extensive scientific literature about salmon (Quinn 2005, Lackey et al 2006a), but the reality is that the future of wild salmon largely will be determined by factors outside the scope of science (Montgomery 2003, Lackey et al 2006b). More specifically, to effect a long-term reversal of the downward trajectory of wild salmon, a broad suite of related public policy issues must be considered:

- *Hydroelectric energy — how costly and reliable does society want energy to be given that wild salmon ultimately will be affected by providing the relatively cheap, carbon-free, and reliable energy produced by hydropower?*

- *Land use — where will people be able to live, how much living space will they be permitted, what activities will they be able to do on their own land, and what personal choices will they have in deciding how land is used?*

- *Property rights — will the acceptable use of private land be altered and who or what institutions will decide what constitutes acceptable use?*

- *Food cost and choice — will food continue to be subsidized by taxpayers (e.g., publicly funded irrigation, crop subsidies) or will the price of food be solely determined by a free market?*

- *Economic opportunities — how will high-paying jobs be created and sustained for this and subsequent generations?*

- *Individual freedoms — which, if any, personal rights or behavioral choices will be compromised or sacrificed if society is genuinely committed to restoring wild salmon?*

- *Evolving priorities — is society willing to substitute hatchery-produced salmon for wild salmon and, if so, will the ESA permit this?*

- *Political realities — will society support modifying the ESA such that salmon recovery expenditures can be shifted to those watersheds offering the best chance of success?*

- *Cultural legacies — which individuals and groups, if any, will be granted the right to fish and who or what institutions will decide?*

- *Indian treaties — will treaties between the United States and various tribes, negotiated over 150+ years ago, be modified to reflect today's dramatically different biological, economic, and demographic realities?*

- *Population policy — what, if anything, will society do to influence or control the level of the human population in California, Oregon, Washington, and Idaho or indeed the U.S. as a whole?*

- *Ecological realties — given likely future conditions (*i.e.*, an apparently warming climate), what wild salmon recovery goals are biologically realistic?*

- *Budgetary realities — will the fact that the annual cost of sustaining both hatchery and wild salmon runs in California, Oregon, Washington, and Idaho exceeds the overall market value of the harvest eventually mean that such a level of budgetary expenditure will become less politically viable?*

These are a few of the key policy questions that are germane to the public debate over wild salmon policy. Scientific information, while at some level relevant and necessary, is clearly not at the crux of the wild salmon policy debate. Scientists can provide useful technical insight and ecological reality checks to help the public and decision makers answer these policy questions, but science is only one input (Policansky 1998, Scarce 2000, National Research Council 2012).

Historical Context

The question of whether wild salmon will continue to exist in the western United States is not new (Lichatowich 1999, Montgomery 2003). In California, Oregon, Washington, and Idaho, the decline started in earnest with the California gold rush. By the 1850s, excessive harvest and the impacts of mining activities on spawning and rearing habitat were decimating salmon in streams surrounding the California Central Valley. In response, by the 1870s the Federal government had begun what would eventually become a massive hatchery program in an unsuccessful attempt to reverse the decline (Taylor 1999). A similar salmon scenario followed gold discoveries in other locations. By the late 1800s, supplemental salmon stocking from hatcheries was widespread from California to Washington.

Even the massive Columbia River salmon runs had been greatly reduced by the end of the 19th century, largely due to minimally regulated fishing and loss of habitat due to nominally regulated land practices such as mining, farming, ranching, and logging (National Research Council 1996, Lackey et al 2006c). In 1894, the head of the agency that preceded NOAA-Fisheries proclaimed to Congress that the Columbia's runs were in very poor condition and declining. Prior to 1933, the year the first main-stem dam on the Columbia was completed, the total Columbia salmon run had been reduced to one-fifth or less of the pre-1850 level. One can argue that the most severe Columbia River salmon decline took place in the 19th century — not the 20th or 21st centuries — though that is not to suggest that the latter two centuries have been favorable ones for salmon.

In California, Oregon, Washington, and Idaho, supplemental stocking of juvenile salmon spawned and raised in hatcheries has long been used to sustain salmon runs at levels sufficient to support fishing (Taylor 1999). The majority of salmon runs that currently support fishing are now of hatchery origin (Schoonmaker et al 2003). Advocates for restoring wild salmon runs often assert that salmon originating from hatcheries are an imperfect substitute for naturally produced (wild) salmon. Further, many analysts have concluded that large-scale hatchery programs actually hindered the recovery of wild salmon because the relatively large numbers of hatchery produced fish enable policy makers to allow salmon fishing to continue (Lichatowich 2013). Whether it is done in the open ocean, coastal waters, or river environments, fishing for salmon when a run is dominated by hatchery origin fish will inevitably lead to the capture and death of some wild fish even though fishing regulations may require the release of captured

wild salmon. Other opponents of hatcheries argue that the straying or intentional dispersal of hatchery fish to different streams over many decades has resulted in a massive mixing (and weakening) of the native gene pool (Taylor 1999). Hatchery origin salmon do interact ecologically with wild salmon and, depending on the desired management goal, the effect can be viewed as either positive or negative (Pearsons 2008). Given the current relatively low abundance of wild salmon, the absence of supplemental stocking from hatcheries would mean that salmon fishing would not currently be viable in California, Oregon, Washington, and Idaho at least for the next few decades.

As indicated earlier, the salmon issue is full of paradoxes. For example, no biological species of Pacific salmon (Chinook, coho, sockeye, chum, pink, and steelhead) is currently in danger of extinction, but many distinct, locally adapted populations (also called runs or stocks) have been extirpated and hundreds more are at risk (Gustafson et al 2007). North American stocks that spawn in the "north" (northern British Columbia, Yukon, and Alaska) are generally doing well (with exceptions), but most wild stocks that spawn in the "south" (California, Oregon, Washington, and Idaho) are not (Augerot 2005).

The decline in wild salmon runs was caused by a well-known but poorly quantified combination of factors, including: unsustainable harvests from earlier commercial, recreational, and subsistence fishing; blockage of upriver habitat by dams built for electricity generation, flood control, and irrigation, as well as for many other purposes; loss of spawning and rearing habitat from various mining, farming, ranching, and forestry practices; unfavorable ocean or other climatic conditions; reduced stream flow caused by diversions of water for agricultural, municipal, or commercial needs; hatchery production to supplement diminished salmon runs or to produce salmon for the retail market; predation by marine mammals, birds, and other fish species; competition, especially with exotic fish species; diseases and parasites; and many others (Knudsen et al 2000, National Research Council 1996, 2004, 2012).

Salmon experts continue to study and debate what proportion of the decline in wild salmon is attributable to which factor (Quinn 2005, Naiman et al 2012). Having participated in many multi-organizational salmon science and policy meetings, I have observed that many affected organizations have developed, or funded the development of, sophisticated assessments of salmon populations that usually end up — probably not surprisingly — supporting their organization's favored policy preference. All the major organizations that participate in the salmon policy recovery disputes employ or at least have access to scientists. No one, not even the most astute salmon scientist, knows for sure the relative importance of the various factors that caused the decline of wild salmon and therefore scientific debate is to be expected. Debate over scientific issues, however, often reflects clashing ethical attitudes, personal beliefs, and policy preferences (Policansky 1998, Scarce 2000).

There is also the incongruity of *apparent* high salmon abundance with simultaneous concern about extinction. Try explaining to the average shopper that salmon are at risk of

extinction when fresh salmon are available year round at the local grocery store. Most wild salmon sold in California, Oregon, Washington, and Idaho now come from Alaska and northern British Columbia. Salmon are still relatively abundant in these northern locations because of comparatively unaltered spawning and rearing habitat, reasonably restrictive regulations to control harvest, and favorable ocean conditions (Lackey et al 2006c). Also, large quantities of "farm-raised" salmon are available year round from many sources (e.g., British Columbia, Norway, Scotland, Chile, and New Zealand).

In California, Oregon, Washington, and Idaho, salmon fishing rights guaranteed by treaties between certain Indian tribes and the United States Government further complicate salmon recovery. Tribal governments with treaty-established fishing rights are in the legal position to co-manage salmon runs with State governments. Such an unusual legal context is one more policy feature that also must be considered when assessing the range of salmon policy options. Tribal governments have become major players in salmon policy debates, as have many large and relatively well-funded non-governmental advocacy groups.

Salmon Recovery Successes

The various salmon species are impressively resilient, but the few recovery successes for *wild* salmon have been in locations where salmon spawning and rearing habitat was in comparatively good condition, migratory blockages from dams or other obstructions were not present or were minimal, and harvest occurred at levels that assured that sufficient numbers of adults reached the spawning grounds. The sockeye salmon runs of the Fraser River, British Columbia, are the best documented long-term example of at least partial recovery after decimation. In this case, the cause was the substantial 1914 Hell's Gate rockslide that hindered salmon migration (Roos 1991). Sockeye salmon runs recovered appreciably after fish passage was improved, stringent harvest controls were implemented, and other vigorous management actions were taken.

The resilience of salmon was also illustrated when a landslide (about 500 years ago) blocked the Columbia River just east of Portland and salmon were thus prevented from reaching upriver streams to spawn (O'Connor 2004). After the slide was breached naturally, salmon eventually reestablished themselves in streams above the blockage. Such blockages of the Columbia River and its tributaries almost certainly occurred at various other times over the past several thousand years.

In both the Fraser River and Columbia River blockages, freshwater salmon habitat was in excellent condition above the obstruction. Presently, however, there are few locations in California, Oregon, Washington, or Idaho where high-quality spawning and rearing habitats are intact (pre 1850 condition) and accessible to salmon. Today, river and stream blockages In

California, Oregon, Washington, and Idaho have left 44% of this original spawning and rearing habitat *inaccessible* to returning salmon (McClure et al 2008).

Endangered Species Act

Beyond the usual suite of historically competing policy priorities found in most natural resources issues, for the past 20 years, the ESA has become the major policy driver of salmon recovery (Lackey 2001b, Lichatowich 2013). Advocates of salmon recovery have used the ESA to force many changes in salmon policy, but this has also resulted in several policy paradoxes. For example, threatened or endangered salmon are the only ESA-listed animals for which government routinely licenses large numbers of people (i.e., fishermen) to harvest them. Further, if society's paramount salmon concern was with the depleted condition of wild salmon runs in California, Oregon, Washington, and Idaho, government agencies could simply close salmon fishing, cease supplementing runs with hatchery releases, and wait to see if wild salmon runs rebounded. Recreational, commercial, and Indian fishermen would object for various reasons, but most people would not be affected by a ban on fishing or stocking hatchery-origin salmon. Furthermore, farm-raised salmon (from British Columbia, Chile, Scotland, and Norway) and wild salmon (harvested in British Columbia and Alaska) would remain abundant and could continue to supply the retail market — and taxpayers would save hundreds of millions of dollars by closing the hatchery system and eliminating the subsidies currently needed to maintain salmon runs.

In addition to the ESA goal of restoring wild salmon, there is the broadly supported goal of sustaining recreational, commercial, and Indian fishing. Other support for continued hatchery operations comes from governmental organizations. State and tribal fish and wildlife agencies usually operate salmon hatcheries with funds provided by the Bonneville Power Administration, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, an assortment of private and public power companies, and sale of fishing licenses. The loss of these funds and jobs would be bureaucratically traumatic to the recipient state agencies.

Ultimately, listing wild salmon as endangered or threatened as defined by the ESA means that all stakeholders, not just fishermen, are affected. As mandated by court decisions, efforts to protect or restore wild salmon often conflict with a suite of other individual and societal priorities (Policansky 1998). For example, two of the most visible contemporary examples of such conflict are the ongoing debate over how to balance Columbia River electricity generation with salmon survival, and the contentious lawsuits over how to divide up scarce Klamath Basin water among threatened salmon, endangered suckers, migratory waterfowl, treaty Indian tribes, farmers, and a host of other demands.

I have often heard colleagues involved in ESA salmon conflicts, usually in informal settings, characterize the ESA as a naive piece of legislation in search of a credible public policy

goal. The ESA's consultation requirements aimed at avoiding actions that could jeopardize the continued existence of protected salmon runs apply only to "Federal actions," but arguably some of the most important actions affecting at-risk species occur in the private sector, and these are usually beyond the scope of the ESA. Critics have long doubted whether Congress four decades ago really understood the policy implications of passing the ESA. Most of the discussion at the time, these critics argue, involved the status of bald eagles and California condors. Was it anticipated that the ESA's grand, but ambiguous wording would result in sweeping Court interpretations? More specifically for salmon, did senators and congressmen who voted for the bill grasp the Act's ultimate policy implications? Not likely — one point upon which both critics and supporters of the ESA agree (Lackey 2001b).

Supporters of the Act, on the other hand, maintain that the ESA is forcing society to make the necessary, though painful, sacrifices for the future well-being of society or, perhaps, even society's very survival. What would be the status of wild salmon in California, Oregon, Washington, and Idaho had the ESA not been invoked? They assert that while the ESA may not be perfect, it is needed more than ever, as declines in salmon populations clearly attest. Although there may be references to the economic value of salmon fishing, salmon for some segments of society is a cultural icon. To other policy advocates, salmon may be a surrogate for the overall "health" of the natural environment. To yet other advocates, the fundamental policy debate is whether humans have a duty to save wild salmon from extinction.

Recovery Goals and Objectives

Presupposing, abstractly at least, that society regards "saving" or "recovering" wild salmon populations as a worthwhile endeavor, substantial tension exists over what the *unambiguous* and *specific* recovery goal ought to be (Lackey 2003). For example, should the policy goal be simply to save from extinction a biological *species*, an evolutionarily significant unit, or an individual salmon run? Such a policy objective (e.g., saving a species, evolutionarily significant unit, or run) can be achieved by conserving relatively low numbers of wild salmon (i.e., museum or remnant runs), but such numbers would be insufficient to sustain fishing. Conversely, from a treaty rights perspective, advocates argue that the appropriate salmon recovery goal must be at a population level sufficiently robust to permit sustainable tribal fishing. Or, from the perspective of recreational and commercial fishermen, maintaining salmon runs at sufficiently high levels required to sustain their harvests should be the overarching goal, but achieving this goal requires heavy reliance on supplemental stocking from hatcheries. Perhaps even more contentious, who decides which goal is appropriate?

Beyond any ESA requirements, a much more challenging recovery objective is to increase runs of wild salmon to levels that would sustainably support fishing. Restoring wild salmon runs across their entire range to levels prior to 1850, or anything close to those levels, is not realistic. Almost certainly this objective is not achievable with wild salmon unless human

impacts are reduced to pre-1850 levels. More fundamentally, will some advocacy groups continue to demand that salmon runs comprise entirely wild fish to achieve whatever level of recovery demanded? If recovery success is constrained to wild fish, it becomes much more challenging and would be especially difficult to produce enough wild fish to support significant recreational, commercial, and tribal fishing. If hatchery fish are used to sustain large salmon runs and salmon fishing is permitted, there will continue to be adverse effects on the relatively small portion of that run that is wild-origin salmon, but what level of adverse effect on wild salmon is acceptable to society? Given the substantial societal and monetary costs to restore wild salmon, perhaps much of the public would opt for using *hatcheries* to sustain salmon runs, in spite of the adverse effects on wild salmon. Thus, there is no inherently best approach to recovery, but rather a suite of alternatives with "best" largely being a function of which vision of the recovery objective one accepts.

No one is bent on eradicating salmon. Further, scientists usually have a pretty solid assessment of the major causes of the long-term declines in salmon populations, even if the relative importance of the causes is open to debate (National Research Council 1996, 2012). Rather than sinister motives or lack of knowledge, society makes choices by choosing between *desirable* but conflicting policy alternatives. For *every* recovery option, benefits come with costs. Thus, achieving the goal of restoring wild salmon engenders some of the features of a zero-sum game (Lackey 2006).

Lessons Learned

Given the complicated policy and ecological context of this natural resource case study, coupled with my personal observations while participating in the bureaucratic process, what specific lessons have I learned? Whether these should be called lessons learned, frustrating truths, or candid realities, I propose that collectively they will circumscribe the future of wild salmon in California, Oregon, Washington, and Idaho.

Salmon Policy Lesson 1 — In spite of its noble intent, the ESA as currently written and interpreted by courts does not well serve salmon recovery, and may be a hindrance in some situations — and such discussions are essentially taboo.

Beginning with the early listings of threatened or endangered populations of salmon two decades ago, the ESA has been a powerful tool in the hands of salmon recovery advocates. Lawsuits have forced the allocation of billions of dollars for salmon recovery, as well as untold additional billions in private costs (Lichatowich 2013). Some advocates press the claim that such expenditures are justified because the bureaucracy is responding to society's wishes. Conversely, others argue that such expenditures are largely a waste of money and, worse, society has never been asked to choose between wild salmon and other competing public policy priorities.

Once a species is deemed at risk of extinction, then the full force of ESA comes into play. In California, Oregon, Washington, and Idaho, many wild salmon runs are at risk because of varied and collective actions of the human population. Wild salmon runs in the worst condition are almost always in rivers and streams least likely to ever support significant wild runs. There are, however, rivers and streams in relatively better condition (from a salmon perspective), but salmon runs in these environments are not at-risk and therefore receive little of the benefit of ESA-mandated expenditures. Some analysts argue that recovery resources ought to be spent on watersheds with the greatest chance of sustaining wild salmon, not in watersheds where success is very unlikely. Critics lambast this approach as a form of wild salmon *triage*. It is highly doubtful whether ESA has the flexibility to permit writing off certain rivers and streams (for wild salmon) and moving the recovery dollars to places where achieving success would be much easier. For example, what if the billions of dollars spent on restoring wild salmon to the California Central Valley and the Columbia River had been spent on restoring salmon to the coastal watersheds of northern California, Oregon, and Washington?

After watching such recovery debates play out for decades and in spite of the social turmoil caused by ESA, it looks to me like society has already made a choice relative to the future of "wild" salmon in California, Oregon, Washington, and Idaho. Salmon runs are now generally less than 5% of the 1850 levels, most of the current runs in these four states are of hatchery origin, and society is not willing to alter lifestyles to reverse the long-term decline. ESA will not greatly alter the long-term trajectory for wild salmon. To be fair, however, no one knows what would have happened to wild salmon had the money *not* been spent, although it is likely that they would be worse off and, very likely, in some cases, extirpated.

In my interactions with senior government *bureaucrats*, they generally recognize most of the scientific and policy facts and realities surrounding wild salmon recovery. I have also found that *politicians* also generally recognize the facts and realities, at least in private. Those in leadership roles with *nongovernmental* advocacy organizations recognize them. Most definitely, knowledgeable salmon *technocrats* (including scientists) recognize the facts and realities. In short, the overarching essential "facts of the case" are rarely in dispute, but the probability of success of a specific recovery effort often is in dispute.

As required by ESA and other laws and policies, hundreds of millions, if not billions, of dollars continue to be spent to recover wild salmon (Lichatowich 2013). Such funding distorts the behavior of individuals and organizations. Bureaucratic, professional, and personal conflicts of interest, both real and perceived, abound. Because agencies are obtaining large amounts of funding to try to reverse the decline, they are not likely to point out publicly the obvious inadequacies of current recovery plans. Because many scientists obtain significant research funding to work on interesting scientific questions, they are not likely to point out the obvious defects in recovery plans. Because advocates from nongovernmental organizations (and their lawyers) are well funded from membership fees and taxpayer reimbursed costs for their

lawsuits, they are not likely to point out the obvious. Because politicians use the argument that they are *already* allocating billions to recover salmon runs, additional unpopular decisions do not have to be made so they too are not likely to point out the obvious flaws in salmon recovery strategies.

Salmon Policy Lesson 2 — Fisheries scientists, managers, and analysts are systemically encouraged to avoid explicitly conveying unpleasant facts or trade-offs to the public, senior bureaucrats, or elected officials.

Over my career and involvement with salmon recovery, one fascinating aspect was the recurring recommendation, even a plea, from some colleagues to "lighten up" and be more *optimistic* and *positive* in assessing the future of wild salmon (Lackey 2001a). Regarding salmon recovery, I am firmly in the camp that scientists and policy analysts ought to be blunt, realistic, and avoid both pessimism and optimism. Many colleagues tend to urge "realists" to abandon blunt assessments and forthright honesty in favor of offering a more encouraging tone of optimism.

Such a message to "lighten up" is also reflected in the comments of some colleagues in reviewing salmon recovery manuscripts. For example, a common sentiment is captured by one reviewer's comment on a manuscript: *"You have to give those of us trying to restore wild salmon some hope of success."*

In contrast, some colleagues, especially veterans of the unending political conflict over salmon policy, confessed their regret over the "optimistic" approach that they had taken during their careers in fisheries, and they now endorse the "tell it like it is" tactic. They felt that they had given false hope about the effectiveness of fishways, hatcheries, and the ability of their agencies to manage mixed stock fishing. Many professional fisheries scientists have been pressured by employers, funding organizations, and colleagues to "spin" fisheries science and policy realism to accentuate optimism. Sometimes the pressure on scientists to cheerlead is blunt; other times it is subtle. For example, consider the coercion of scientists by other scientists (often through nongovernmental professional societies) to avoid highlighting the importance of U.S. population policy on sustaining natural resources (Hurlbert 2013). The existence of such institutional and organizational pressure is rarely discussed except among trusted colleagues; nevertheless it is real.

Other colleagues took professional refuge in the reality that senior managers or policy bureaucrats select and define the policy or science question to be addressed, thus constraining research. Consequently, the resulting scientific information and assessments are often scientifically rigorous, but so narrowly focused that the information is only marginally relevant to decision makers. Rarely are fisheries scientists encouraged to provide "big picture" assessments of the future of salmon. Whether inadvertent or not, such constrained

information often misleads the public into endorsing false expectations of the likelihood of the recovery of wild salmon (Lackey 2001a, Hurlbert 2011).

For salmon experts, is adopting unfounded "professional" optimism a harmless adaptive behavior of little import? After all, "think positive" slogans are a hallmark of many self-improvement programs. What is wrong is that optimism does not convey what is happening with wild salmon and it allows the public, elected officials, and fisheries managers to escape the torment of confronting species triage. No salmon expert ever seriously argues that you can have wild salmon everywhere they once were, but few are willing to be explicit about identifying those locations where the cost is high and chance of success is low (Lackey 2001a).

I believe that fisheries scientists should be *realistic* and avoid being either optimistic or pessimistic regarding the prospects of salmon recovery. This professional stance does not covertly argue in favor of an "imperative" to save wild salmon or any other species regardless of the cost to society, nor does it necessarily support a "defeatist" strategy. Such choices, at least in democratic forms of governance, are made by an informed public that is aware of the difficult tradeoffs. Further, restoring wild salmon is only one of many competing, important priorities and the public is entitled to be accurately informed about the long-term prospects of success.

In discussions about the future of wild salmon, for scientists at least, it is easy to find comfort in debating the scientific nuances of hatchery genetics, evolutionarily significant units, dam breaching, fishing regulations, predatory bird and marine mammal control, habitat restoration, and atmospheric and oceanic climate trends. This focus on scientific details, often couched in optimistic rhetoric, can unintentionally mislead the public about the realities of the situation (Hurlbert 2011). As discomforting as it may be to disclose the future of wild salmon relative to society's apparent values and preferences, fisheries scientists should provide information and assessments that are policy-relevant but policy-neutral, understandable to the public and decision makers, and scrupulously realistic about the future.

It is not only fisheries scientists, managers, and analysts who avoid explicitly conveying unpleasant facts or trade-offs to the public. Such an inclination exists on the part of elected and appointed officials. The 165 year track record of salmon policy makers in California, Oregon, Washington, and Idaho has demonstrated an unceasing propensity on the part of elected and appointed officials to slip into the behavior of "domesticating" the policy issue. By this, I mean the practice of taking difficult, divisive policy issues (i.e., salmon recovery) off the political table until a solution emerges or the problem disappears by solving itself (e.g., the species is extirpated or a political consensus emerges on a recovery strategy) (Lach et al 2006). Relative to salmon recovery, the most common indicators of "domestication" are funding more research or scientific reviews, holding more workshops and venues to get stakeholders involved through collaboration, forming more planning teams to assess policy options, and tweaking current regulations or policies. Starting in the 1850s with the first efforts by politicians to

reverse the decline of wild salmon in the California Central Valley, policy domestication through generous funding of such activities has provided the public with the illusion of progress in salmon recovery (Lichatowich 1999, Montgomery 2003).

To appreciate the evolution of the current political circumstance, note that political actions to *domesticate* salmon recovery are easier than political actions that will *reverse* wild salmon decline. Thus, few elected or appointed officials explicitly propose ways to change political realities about recovery of wild salmon. Instead, they suggest permutations of existing policy options (e.g., revise the ESA, protect more or different salmon habitats, modify hatchery practices to reduce adverse effects on wild runs, change K-12 education to stress the importance of wild salmon, or somehow transform attitudes through public awareness).

Salmon Policy Lesson 3 — For wild salmon, the rules of commerce, especially trends in international trade, tend to work against increasing their numbers.

The rules of commerce and the marketplace over the long-term are not friendly for wild salmon (Lackey 2005, Lichatowich 2013). The drive for near-term, low-cost production in free market economies is a widely professed approach to trade, both within nations and among nations. Wild salmon policy protagonists argue whether so called "free" markets are actually free, but my purpose is not to argue either in favor of or against such a philosophy of commerce. Rather, I conclude that the market will continue to affect adversely the status of wild salmon runs in California, Oregon, Washington, and Idaho.

There appears to be a general presumption that "free trade" and market-driven economies will continue to be a dominant government policy through this century because the public broadly supports them. One consequence is that non-economic values, such as preserving at-risk wild salmon runs as required by ESA, tend not to get weighted very heavily in decision-making (Lichatowich 2013). There is considerable political rhetoric to modify the current rules of commerce (e.g., "fair" trade), but it is not clear what these modifications would be, much less how they would affect salmon recovery (Lackey 2005).

The tendency of market forces to put downward pressure on wild salmon runs is not inherently good or bad, just a fact. For example, electronics are generally obtained from wherever they can be assembled at least cost. Automobile assembly plants typically end up wherever manufacturers can produce cars most inexpensively. Electricity tends to be generated in the most cost-efficient way. Wheat is mostly produced where it can be grown most productively and consistently. Wood also tends to be produced where trees can be grown and harvested most efficiently and milled at the lowest price. As many observers point out, it may not be a completely free market (e.g., the widespread use of taxpayer subsidies to manipulate the market), but politically, a majority seems to accept the efficacy of free trade and free markets.

Individual and collective choices are not driven entirely by cost. Perception, personal values, preferences, and risk tolerance play important roles. Consider how society chooses to generate electricity. Power from hydroelectric dams is usually inexpensive and generation does not result in greenhouse gas emissions, but dams are not beneficial to salmon. Wind power is comparatively expensive, but once installed, does not produce greenhouse gas. Unfortunately, it is not reliable, nor is it ideal for birds, bats, or vistas, at least in the opinion of many. Depending on a person's perceptions, nuclear, coal, natural gas, solar, biofuels, and wave power all have their own strengths and weaknesses for generating electricity; thus it is not merely cost that determines a market preference, yet cost is enormously important.

The benefits of free market economies are well recognized, but there are also consequences that are at odds with wild salmon recovery. For example, in the marketplace, how much more are people willing to pay for food, electricity, or transportation produced in ways that will not degrade salmon habitat? Any serious effort to answer this question must avoid the twaddle that such goods and services can be produced just as cheaply in a "salmon-friendly" manner. As with all policy choices, there are winners and losers — a fact that should be made clear.

Searching for the ever tantalizing win-win wild salmon recovery solution ends up frustrating everyone. Except for the most trivial policy aspects of wild salmon recovery, compromise is necessary to craft a proposed policy that is politically possible. Thus, salmon policy analysis ends up revealing many of the characteristics of a classic zero-sum decision-making game.

Salmon Policy Lesson 4 — Competition for critical natural resources, especially for water, will continue to increase and will work against recovering wild salmon.

It could be argued that this "lesson learned" borders on a blatantly obvious claim (e.g., salmon need water), but this biological reality is often overlooked in policy analysis and forecasting. Many watersheds in California, Oregon, Washington, and Idaho suffer from human induced water shortages, but unless the competition for scarce water explodes into open political conflict, most people are oblivious to the magnitude of the challenges. Even with media stories about impending water scarcity, most written in a doom and gloom style, our insatiable demand for fresh water shows little sign of easing.

I am not declaring that allocating water for salmon is more important than allocating it for alternative uses, but, as competition for scarce water intensifies, how will advocates for wild salmon fare relative to advocates for competing priorities such as water for domestic use, irrigation, manufacturing, generating electricity, and a host of other needs?

The old and continuing water war in the Klamath Basin, along the California-Oregon border, gives us an indication of the probable future throughout California, Oregon,

Washington, and Idaho. A decade ago, national newspapers described Klamath Basin farmers defying law enforcement agents and illegally opening locked valves and releasing water to irrigate their fields. The television evening news showed Klamath River choked with dying salmon caused by low water flows, poor water quality, and diseases. Lawyers from various competing interest groups dueled in court over who will get how much water. At the end of the day, every faction in the battle was dissatisfied with the result, feeling that their interest did not get a fair share of the water, and grappling for ways to be more politically effective in the next water battle.

If the human population of California, Oregon, Washington, and Idaho stays on track and expands several fold through this century, how will wild salmon recovery programs stack up against competing demands for scarce water?

Salmon Policy Lesson 5 — Because of the increasing numbers of humans, their aggregate demand for natural resources will continue to swell, thus tending to work against increasing the abundance of wild salmon species — and this fact is rarely made clear to the public.

Assuming that there are not major changes in immigration/population policy in the U.S., the most probable scenario for the human population trajectory through this century for places like California, Oregon, Washington, and Idaho is substantially upward (Lackey et al 2006d). Any serious discussion about the future of wild salmon must consider human population and land use trajectories, but it is not fashionable to raise these issues (National Research Council 1996, Hurlbert 2013).

Environmental advocacy groups avoid highlighting the overarching influence of high population levels even though it dwarfs most of the human behaviors they are trying to modify. Even fish advocacy groups rarely mention it, much less take a clear policy position. It is the proverbial elephant in the room that few want to acknowledge. As one of my colleagues warned me after reading a draft of a paper about the future of wild salmon:

> *"Bob, you are absolutely right, most people already know it, and that's exactly why you should let it rest. Back off. You'll leave the proponents of wild salmon recovery depressed. Worse, you'll have the rest of the audience wondering why you are pontificating on the intuitively obvious. And you run the risk of being attacked as a racist, nativist, xenophobe, cultural imperialist, sexist, or, at the least, an economic elitist."*

Perhaps this is sound advice and I should back off. However, if society wishes to do anything meaningful about moving wild salmon off their current, long-term downward trajectory, then something must be done about unrelenting human population growth in California, Oregon, Washington, and Idaho. It is not simply the number of people that causes problems for wild salmon, but it is also their individual and collective ecological footprint and

the fact that humans and salmon tend to use the lower elevations of a watershed. Protected public lands (e.g., national parks, wilderness areas, and national forests) are often at higher elevation and streams in these locations usually provide little habitat for wild salmon.

What amount of population growth should be expected? The latest demographic forecasts show a *slowing* of the world population (currently 7.2 billion) growth rate through this century with a leveling off toward 2100 (United Nations 2013). Yes, a leveling off is predicted, but at 10.9 billion people. Especially for regions like the Pacific Northwest and the U.S. generally, there is a different story. It is largely one of past, current, and future immigration. Currently, Washington, Oregon, Idaho, and British Columbia are home to 15 million humans. In the absence of policy changes and assuming a range of likely human reproductive rates and migration to the Pacific Northwest from elsewhere in Canada and the United States, by 2100 this region's human population will not be its present 15 million, but rather will be somewhere between 50 and 100 million, a potential quadrupling or more of the region's population by the end of this century.

Consider those 50 to 100 million people in the Pacific Northwest in 2100, and their demands for housing, schools, sewage treatment plants, tennis courts, football stadiums, roads, parking lots, airports, coffee shops, restaurants, stores, electricity, drinking water, pipelines, marinas, movie theaters, ski resorts, golf courses, and on and on. The consumer demand from the millions of current and new residents is immense.

Visualize the western region of the State of Washington and southwestern corner of British Columbia in 2100 with its metropolis of *Seavan*. Seavan morphed into a truly great metropolis as smaller, discrete cities grew together. Seavan in 2100 stretches from Olympia in the south, along Puget Sound northward through the once stand-alone cities of Tacoma and Seattle, and on to Vancouver (BC), east to Hope at the head of the Fraser Valley, and west to cover the southern half of Vancouver Island. Rather than the 6 million people back in 2007, Seavan in 2100 rivals present-day Mexico City and Tokyo with 30 million inhabitants. Or think about the New York City to Boston corridor transplanted to the Pacific Northwest. It is within this context that salmon recovery strategies need to be developed if they have any chance of succeeding.

Regardless of the accuracy of this forecast, population issues are not easy ones to highlight without implying a preferred policy option. After all, there are strategic and financial reasons why the big environmental advocacy groups, most groups in fact, stay clear of population issues these days (Hurlbert 2013). Yet an explicit recognition of the expected overall increase in world population, coupled with the spectacular increases in certain "fill in" regions such as western North America, must be at the core of any credible analysis of potential recovery strategies of wild salmon. Without such recognition, recovery strategies for salmon are doomed to fail.

Salmon Policy Lesson 6 — Individual and collective life-style preferences largely determine the future of wild salmon, and substantial changes must take place in these preferences if long-term downward trends in wild salmon abundance are to be reversed.

This lesson learned is perhaps the most obvious and arguably the most important. For most fisheries scientists, it is easy to assume that wild salmon are near the top of the public's priorities. Just look at the polling results regarding restoring depleted salmon runs. *Everyone* supports salmon and especially wild salmon. But, the fact is that salmon recovery is only one of many priorities that individuals, when not forced to make a choice, profess to rank highly. When forced to make a choice, salmon recovery drops substantially in importance as compared to other priorities. Society's collective behavior, not public opinion polls, not thick recovery plans, but people's individual and collective behavior, gives us the best indication.

Consider the following example to illustrate this lesson learned. In 1991 the first salmon "evolutionarily significant unit" in California, Oregon, Washington, and Idaho was listed under the terms of the ESA. With the listing of Snake River sockeye salmon as a legally protected species, the policy debate shifted away from restoring salmon runs in order to support fishing — to protecting wild salmon runs from extirpation, two very different policy objectives. Starting with this first ESA listing, followed by many others, protecting at-risk runs of wild salmon won out over maximizing fishing opportunities. The residents of the United States *apparently* made a choice about the relative importance of wild salmon compared to other policy priorities. Or did they?

Jump ahead 10 years to 2001, only a decade after the first salmon listing; ongoing electrical blackouts and brownouts in California prompted the U.S. Bonneville Power Administration to declare a power emergency, abandon previously agreed upon interagency salmon recovery commitments, and generate electricity at maximum capacity using water reserved to help salmon migrate. In one of the most striking and clear-cut examples of choices between competing societal priorities, electricity for air conditioners and refrigerators won out over both wild and hatchery-bred salmon. Perhaps even more instructive, there was scant public opposition. There were no street protests. There were minimal legal challenges. I do not remember any elected officials publicly pleading for salmon. No environmental group blanketing the Internet with calls to mobilize in defense of salmon. Even among the wild salmon advocates, there was nearly complete silence.

The lesson to be learned here is that many people will support "saving wild salmon" so long as *their* individual life-styles are not greatly impacted. Over the past 165 years, there have been many of these choices, often contradictory, and these choices collectively reflect the *relative* societal priority of recovering wild salmon. These choices are tradeoffs, and society continues to make them, and they are a real measure of the relative importance of wild salmon. That is not good or bad, just a fact, however unwelcome to wild salmon advocates.

Now, I am not cheerleading for wild salmon or for any other species, or for electricity, or for property rights, or for hatcheries, or for having a McDonalds and Starbucks on every corner, but it is naive to consider salmon recovery for most people as anything but a minor element in a constellation of competing, often mutually exclusive policy preferences.

Conclusion

There remains a near pervasive delusion that wild salmon in California, Oregon, Washington, and Idaho *could* be greatly increased concurrent with the present upward trajectory of the region's human population coupled with most individuals' apparent unwillingness to reduce *substantially* their consumption of resources and standard of living. Few salmon advocates argue publicly that society *must* make these substantial and contentious changes to recover wild salmon. Further, the *implicit* public optimism of salmon scientists and technocrats about restoring wild salmon tends to perpetuate this avoidance of reality. At least some of this delusional reality is validated by salmon technocrats being influenced by funding provided through salmon recovery programs.

I am not arguing that we *ought* to change any current public policy or our individual priorities, but I do think that experts should be candid about how society's priorities and individual choices affect salmon runs. An inescapable fact is that the increase in the human population in California, Oregon, Washington, and Idaho that we currently anticipate will create a serious barrier to achieving any significant long-term recovery of wild salmon.

There are strategies that could successfully restore wild salmon to California, Oregon, Washington, and Idaho, but each requires major and politically divisive choices (Lackey, et al 2006). It is not technical inadequacies that preclude such recovery strategies from being implemented. Rather, it is the unpleasant resulting consequences arising from implementation. The economic and societal costs of implementing a wild salmon recovery strategy that has a good chance of restoring wild salmon runs to significant, sustainable levels in California, Oregon, Washington, and Idaho would be extremely high. Based on the experience of the past 165 years, it is unlikely that society collectively is willing to bear such costs.

To succeed, a wild salmon recovery strategy must change the trajectory of the major policy drivers or that strategy will fail; it will be added to a long list — 165 years in the making — of noble, earnest, and failed salmon recovery strategies. If we only continue to spend billions of dollars in quick-fix efforts to restore wild salmon runs, then in most cases these efforts will be only marginally successful. The billions spent on salmon recovery might be considered "guilt money" — modern-day indulgences — a tax society and individuals willingly bear to alleviate their collective and individual remorse. It is money spent on activities not likely to achieve recovery of wild salmon, but it helps people feel better as they continue the behaviors and choices that preclude the recovery of wild salmon.

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Dr. Bob Lackey is professor of fisheries science at Oregon State University. In 2008 he retired from 27 years with the Environmental Protection Agency's national research laboratory in Corvallis where he served as Deputy Director among other senior science and management jobs. Since his very first fisheries job mucking out raceways in a California trout hatchery, he has worked on an assortment of natural resource issues from various positions in government and academia. His professional assignments involved diverse aspects of natural resource management, but mostly he has operated at the interface between science and policy. He has published over 100 articles in scientific journals. Dr. Lackey has long been an educator, having taught at five North American universities and currently teaches a graduate course in ecological policy. Canadian by birth, he is now a U.S.-Canadian dual-citizen living in Corvallis, Oregon.

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