Opinion

Wild salmon recovery and inconvenient reality along the west coast of North America: indulgences atoning for guilt?

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The history of efforts to reverse the long-term decline of Pacific salmon in California, Oregon, Washington, Idaho, and British Columbia provides instructive policy lessons for their recovery. From California to southern British Columbia, wild runs of Pacific salmon have declined over the long-term and many have disappeared. Billions have been spent in so-far failed attempts to reverse the decline. The annual expenditure of hundreds of millions of dollars continues, but a sustainable future for wild salmon in this region remains elusive. Despite documented public support for restoring wild salmon, the long-term prognosis for a sustainable future appears problematic. Fisheries scientists and others continue to craft restoration plans, but an effective, politically viable approach has yet to emerge, which will actually restore and sustain most runs of wild salmon in the region. For wild salmon, restoration options exist that offer both ecological viability and appreciably lower social disruption, but these options also tend to have more modest restoration objectives. Perhaps these billions of dollars being spent to recover wild salmon should be considered 'guilt money'—modern-day indulgences—a tax that society and individuals willingly endure to alleviate collective and individual remorse. It is money spent on activities unlikely to achieve the recovery of wild salmon, but perhaps it helps many feel better as we continue the behaviors and choices that essentially preclude their recovery.

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INTRODUCTION

The striking decline of salmon runs in California, Oregon, Washington, Idaho, and southern British Columbia has been typical of those that have occurred elsewhere.[1] 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.[2] Thus, what *has* happened—and *is* happening—to wild salmon in California, Oregon, Washington, Idaho, and southern British Columbia is the latest example of a pattern that has played out numerous times in other regions of the world for salmon[1] and other fish species.[3]

Prior to the 1800s, large spawning migrations (runs) of Atlantic salmon were found in many coastal rivers of western Europe and eastern North America.[4] By the middle to late 1800s, many of those runs were drastically reduced, concurrent with human population increase and economic development.[2] 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,

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FIGURE 1 | Runs of wild salmon in California, Oregon, Washington, and Idaho are typically less than 5–10% of their historical size. Many runs are extinct (Photo: Robert T. Lackey).

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.[5] Nevertheless, Pacific salmon, found on both sides of the North Pacific, have also declined substantially from historical levels, especially in the southern portion of their distribution, although not as dramatically as Atlantic salmon (Figure 1).[6,7] 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, although there are some large hatchery programs in these regions as well.[5,6] There are indications that salmon numbers are increasing in Arctic habitats, presumably due to an overall warming trend.[8]

The discoveries of gold in California (1848) and elsewhere later resulted in substantial adverse effects on many salmon runs (Figure 2).[9,10] Efforts to protect and restore salmon populations in California,

FIGURE 2 | Starting in 1848, gold mining in and around salmon streams of the California Central Valley decimated salmon runs. Conversely, salmon runs in Alaska and northern British Columbia continue to prosper because those aquatic and terrestrial ecosystems have been minimally altered. (Photo: US Fish and Wildlife Service).

Oregon, Washington, and Idaho began in the early 1850s, and such efforts have been technically challenging, socially contentious, and politically painful.[11] Overall, past recovery efforts for wild salmon (in contrast to salmon bred and raised in hatcheries or 'natural origin' salmon, the offspring of hatchery fish that spawned in streams) have been largely unsuccessful.[11,12] Over many decades, thousands of scientists have been involved with salmon recovery efforts, but prospects for recovery of wild salmon remain elusive.[11] Of the nearly 1400 distinct Pacific salmon populations that occurred prior to 1848 in California, Oregon, Washington, and Idaho, an estimated 29% have been extirpated.[13] The remaining populations of wild salmon are greatly reduced, usually at less than 5% of their historical levels.[14] 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 defined by the Endangered Species Act (ESA).

CURRENT POLICY CONTEXT

Despite recent newspaper headlines heralding 'record' salmon runs in some rivers, most salmon runs in California, Oregon, Washington, and Idaho are maintained by releases of hatchery-spawned and raised fish and their offspring that return to spawn in streams (i.e., natural origin salmon). What many think of as *wild* salmon—those whose parents and ancestors spawned naturally in natural habitat—comprise only a minor portion of these runs and their overall abundance is a small fraction of historical levels.[15]

For more than a century and a half, there have been concerted efforts to recover salmon runs

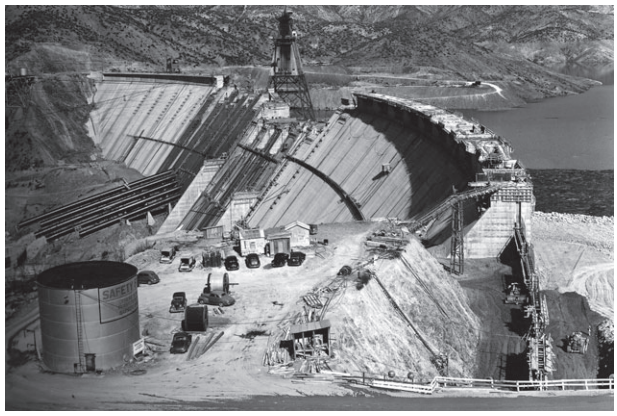

FIGURE 3 | Dams and irrigation structures have greatly altered the freshwater environment for salmon. Other fish species, particularly nonnative ones, have prospered in these altered aquatic environments (Photo: U.S. Army Corps of Engineers).

(Figure 3).[10] During the past three decades, the number and cost of formal recovery efforts for *wild* salmon have substantially increased in large part in response to requirements of the ESA.[15] While using hatcheries to sustain relatively large salmon runs is plausible—although technically challenging and questions remain about long-term sustainability—the requirements of the ESA relative to *wild* salmon has made the role of hatcheries in boosting runs legally contentious.

In my interactions with professional fisheries colleagues over many years, they agree—usually only when speaking unofficially—that current efforts will not successfully recover *wild* salmon to abundances that would assure self-sustainability and support sizable sport and commercial harvest.[16] Such a level of abundance, at best, may still be only a third or less of the typical pre-1850 run size.

Even with the very large expenditures to recover *wild* salmon, what is it that pushes the most knowledgeable people to the stunning conclusion that these well-meaning efforts will fail?

To succeed, a wild salmon recovery strategy must address several overarching and undisputed realities about the west coast of North America that have developed over many years (Figure 4).[17] Without addressing these realities, any wild salmon recovery strategy will fall far short of expectations. It will be added to a long list—well over a century in the making—of noble, but failed salmon recovery strategies. Even if society continues to spend billions of dollars to restore wild salmon runs, these efforts ultimately will be only marginally successful.

What precisely are these realities and how must they be changed to recover wild salmon to even a third of their historical level? In my view, four key realities emerge.

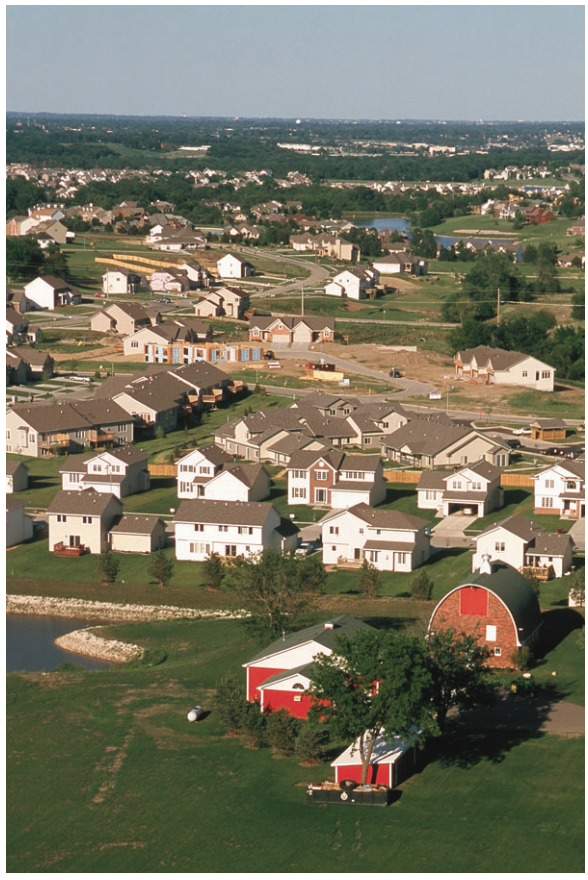

FIGURE 4 | Human population growth is projected to increase several fold during this century in California, Oregon, Washington, Idaho, and British Columbia and will create higher demand for already scarce water resources (Photo: U.S. Army Corps of Engineers).

Reality 1: Overall, wild salmon abundance, especially south of the Canadian border, is very low and has been so for a long time.

Most spawning runs are far less than 10% of their pre-1850 levels. Over two dozen ESA 'species' (distinct population segments) are now listed as threatened or endangered. Many runs have already disappeared and more will follow unless there is a reversal of the long-term downward trajectory.

Reality 2: We have been well aware for a long time of the causes of the dire state of salmon runs along the west coast of North America.

These causes are well documented scientifically and include mining, dams, road and highway construction, logging, over-fishing, farming, water withdrawals, predation on salmon by many species,

FIGURE 5 | Supplemental stocking of salmon produced in hatcheries currently supports most fishing, but hatchery-produced salmon do not fully replace the biological role of wild salmon (Photo: U.S. Army Corps of Engineers).

competition with hatchery-produced salmon and other, often nonnative fish species, and many other causes.[9] Lack of long-term success in salmon recovery is not due primarily to lack of scientific knowledge. For conservation policy issues (as well as many other policy issues), results of psychological studies demonstrate that increasing knowledge through education does not lead to change in human behavior.[18]

Reality 3: Anywhere wild salmon were once plentiful (Europe, Asian Far East, Eastern North America), the decline in their abundance is roughly inversely related to the growth in the human population.

Over decades and centuries, as the human population expanded in regions where salmon were abundant, the size of salmon runs declined. Since 1848, this pattern has also occurred for wild salmon on the west coast of North America.[19] For example, from a pre-1848 human population level of a few hundred thousand, California, Oregon, Washington, and Idaho are now home to 50 million people. Over the same time period, wild salmon abundance in the four states has declined from roughly 50 million to a few million. To forecast the most likely future of wild salmon, consider the regional growth rate of the human population over the past 100 years. Assuming this trajectory continues, the West Coast, by 2100, will be home to somewhere between 150 and 200 million people—a tripling or quadrupling by the end of this century—less than 85 years from now.

Reality 4: It is highly unlikely that most people will accept the substantial life-style and economic changes necessary to recover wild salmon runs to substantial levels.

It is not just the sheer number of humans (Reality 3), but their individual and collective lifestyles and economic choices that reduce the abundance of wild salmon.[9] Although it is commonly acknowledged in the scholarly literature, psychological factors, not biological information, drive behavioral change.[20] In the absence of dramatic changes in personal and collective priorities, future options for restoring salmon runs to significant, sustainable levels will be greatly hampered (Figure 5).

CONCLUSION

Looking toward the future and acknowledging these four apparent realities, society's options for sustaining *existing*—much less *increasing*—wild salmon runs are greatly constrained. Conversely, maintaining sustainable populations of *nonnative* West Coast game fish species (e.g., bluegill, walleye, smallmouth bass, largemouth bass, brook trout, and striped bass) is viable, because these species, unlike salmon, are well adapted to the now greatly altered West Coast aquatic environments. Overall, these and some other nonnative fish species are doing well, but salmon are not.

If society seriously wishes to recover runs of wild salmon, then these inconvenient realities must be acknowledged and changed. For many wild salmon advocates, this blunt message is difficult to accept. The implications of not accepting it, however, are worse. In order to restore substantial, sustainable runs of wild salmon, we cannot be under the illusion that what scientists and technocrats are doing now—as expensive and socially disruptive as it is—will sustainably increase wild salmon runs over the long term.

If society continues to ignore these four inconvenient realities, wild salmon recovery efforts over the long-term will not succeed. Practical experience and research[21] has demonstrated that more emphasis on 'education' (i.e., explain the facts once again) will not likely be successful in changing societal and individual behavior and priorities. Until society collectively addresses these realities, the billions of dollars being spent to recover wild salmon could be considered 'guilt money'—modern-day indulgences—a tax that society and individuals willingly endure to alleviate collective and individual remorse for the continued decline of wild salmon populations.

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