What Would Happen to Columbia River Basin Wild Salmon Runs *if* Hatchery Stocking and Fishing Ended?

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Key Findings:

- *I asked 58 well-known salmon scientists to predict (anonymously) how the overall abundance of Columbia River Basin salmon (including steelhead) would change after 20 years if fishing was stopped and hatcheries were closed.*
- *About 83% predicted that current (wild plus hatchery) salmon abundance (overall Columbia Basin run) would decline without hatchery stocking and fishing.*
- *About 12% predicted that the resulting overall wild salmon abundance would be greater than the current (wild plus hatchery) abundance.*
- *Most surveyed experts predicted that stopping fishing and closing hatcheries would not greatly change the current overall wild-only abundance in the Basin.*
- *Based on these results, salmon fishing and hatchery additions are not currently believed to be among the major drivers of the low abundance of wild salmon in the Columbia River Basin.*
- ***The current overall abundance of wild salmon in the Columbia River Basin (roughly 2-4% of pre-1850s levels) is within the expected range, given the amount and availability of high-quality salmon habitat, past and current ecological changes, and overarching trends in oceanic and climate conditions. Thus, stopping fishing and closing hatcheries likely will not drastically change current wild salmon abundance in the Basin — and it may well drive wild runs even lower, according to many experts.***

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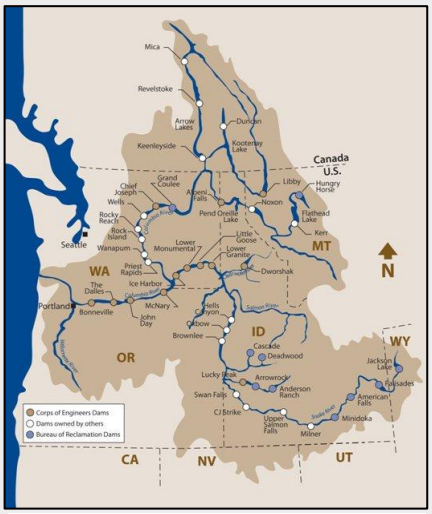
Introduction

Wild (non-hatchery origin) salmon and steelhead in the Columbia River Basin **are not doing well**. Basin-wide, *wild* salmon and steelhead are roughly 2-4% of their pre-1850s levels. Even the *total* (wild plus hatchery) current salmon and steelhead run is **now less than 10-20% of the pre-1850s** levels. About **140 million** ocean-going juvenile salmon and steelhead are released annually from fish hatcheries in the Columbia River Basin. Currently, the annual harvest (i.e., from commercial, recreational, and tribal fishing) is strongly dominated by hatchery-origin fish.

Even without major human intervention, salmon runs (whenever I refer to "salmon," I include steelhead) are notoriously variable annually and decadally. Still, the **overall downward trajectory** has been apparent over the long term (150 years). Interestingly, the current low overall salmon abundance has not shown an obvious continuing downward trend for several decades. Nor has the trend been plainly upward.



*The amount of habitat currently **accessible to salmon is only 45%** of the pre-1850s level. Overall, nearly 1700 miles of habitat is now inaccessible to salmon and steelhead. As well, much of the accessible habitat is very different from pre-1850s conditions.*

Deciding how important it is to preserve wild (vs. hatchery-origin) salmon runs and/or to sustain fishing (vs. myriad competing public policy priorities such as flood control, energy production, agriculture, etc.) is a decision society continues to make, either **explicitly or implicitly**. Of course, scientists do not *make* such tradeoffs, but they should play an important, even essential, role as sources of impartial scientific information and assessments.

One important role is providing **expert judgment** about complex scientific questions that are beyond the capability of the **traditional scientific method**. Thus, scientists are understandably uncomfortable when asked to answer "scientific" questions about policy-relevant questions that the scientific method cannot answer.

To help provide relevant "expert" *scientific* professional judgment to policy and management deliberations, I conducted a "thought experiment" by asking Columbia River Basin salmon and steelhead scientists how (1) stopping **fishing** and (2) closing **hatcheries** would most likely affect the remaining wild runs.

In the persistent political controversy over salmon policy tradeoffs, some advocates argue that one or both changes (i.e., stop fishing and **close hatcheries**) would *increase* the abundance of *wild* salmon in the Basin — perhaps even increase the *wild plus hatchery* salmon abundance. The most well-known example of "close the hatcheries to save wild salmon" advocacy is the Patagonia-produced film ***Artifishal: The Fight to Save Wild Salmon***, which millions have viewed. Many other organizations push similar policy perspectives, although not with a billionaire's financial backing or marketing platform.

Other advocacy organizations assert that continued fishing and hatchery stocking are not currently among the major causes of the very low levels of wild salmon in the Columbia River Basin. An example of such advocacy is the video **Benefishal**, a direct response to the Patagonia-funded film. Such advocates typically argue that the main reason any Basin salmon fishing still exists is *because* of hatcheries.

Either view — and the many nuances between the two — might seem counterintuitive until the **array of past and current policy drivers** is considered.

Ecological Context

As a start, consider how much the physical and biological features of the Columbia River Basin have changed since the pre-1850s. Unlike native salmon and steelhead, non-native anadromous fish species thrive in the highly altered aquatic environment. A simple statistic captures the sobering reality. In 2021, the **Independent Scientific Advisory Board of the Northwest Power and Conservation Council** (ISAB) determined that *". . . in 2019, about 30 times more shad passed over Bonneville Dam than salmonids (around 7.5 million vs. 0.25 million)."* American shad, a non-native anadromous species, is one of *many* non-native fish species that thrive in the present-day Columbia River Basin. **American shad**, walleye, crappie, smallmouth bass, largemouth bass, bluegill, yellow perch, channel catfish, and northern pike are all relatively new species to the Basin. Their success is not surprising to biologists because these species are well adapted to the Basin's current (and likely future) ecological conditions. In stark contrast to *native* salmon

and steelhead, these new arrivals thrive by expanding into much of the highly altered Basin aquatic environment.

It is not that salmon are particularly delicate species, but like all species, they have specific environmental requirements. They can also adjust to some unfavorable conditions. For example, salmon do "stray" to find better environments. One well-known example, the famous **Bridge of the Gods** blockage of the Columbia River around 600 years ago, which prevented salmon upriver migration for several years. When salmon eventually could move past the barrier, they re-colonized the middle and upper Basin fairly quickly. Such blockages were surely common in the Columbia Gorge on the millennial time scale.

Even before the Bridge of the Gods and similar landslides, the **Bretz Floods** scoured the mainstem Columbia multiple times 13,000 - 15,000 years ago. The distribution and abundance of salmon in the Columbia River Basin would drastically change with each flood (and recovery).

Among salmon scientists, the mid- or pre-1850s are typically selected as the baseline period to benchmark current salmon abundance. However, the 1850s were toward the end of the **Little Ice Age**, a relatively cool period (1300s - 1800s) that was likely much more favorable to salmon than the **Modern Warm Period** (1900s -).

Complicating matters further is the biological reality that salmon and steelhead are fairly adaptable and thus survive in diverse habitats across **broad geographic expanses**. As populations, they often successfully extend their distribution into different environments. For example, salmon were successfully introduced and spread widely in **New Zealand**, Chile, Argentina, northwestern Russia, and the **U.S./Canada Great Lakes**. They colonized other rivers from relatively limited initial introductions and often established self-perpetuating runs. For a contemporary and active example, **pink salmon** (a species native to the Columbia River Basin), introduced into northwestern Russia, are now **expanding into rivers in Norway** and probably Sweden.

Caveats aside for the Columbia River Basin, what was the "natural" **abundance of salmon and steelhead in prior times**? Specifically, how many salmon and steelhead did the Basin support before the 1850s — before most human-driven alterations dramatically reduced salmon numbers? After evaluating all available historical reconstruction data, the Columbia River Basin **Independent Science Advisory Board** concluded that the Basin-wide pre-1850s aggregate run was likely in the range of 5 to 9 million adult fish per year, with the most likely level at around 6 million. Some other estimates are higher, with the upper bound at 15-16 million. Approximating the run size nearly two centuries ago is challenging — and such assessments should be accepted cautiously.

These days, fundamental technical questions about the influence of fishing, **hatcheries**, and other factors in controlling the number of salmon (wild and hatchery origin) remain difficult to answer, but have important policy and management implications. For example, many advocates argue that fishing for Columbia River Basin stocks is **only viable** because hatchery releases sustain current runs. Further, and usually, only fin-clipped (hatchery-origin) salmon may be kept, which lessens fishing mortality on wild fish. Without hatchery supplementation, the argument goes, wild runs would be too small to support sustainable harvests at levels demanded by fishing interests.

Classifying a salmon as "wild" requires a degree of arbitrariness. To some, a "native" species may be interchangeable with "wild." To others, "wild" might mean an individual fish whose ancestors were *never* in a hatchery (i.e., not "naturalized"). However, when I use "wild" to classify a salmon, I use the **definition**: *"Any salmon spawned naturally and whose parents spawned naturally."* This choice is subjective and used for communication clarity rather than implying a policy preference. This definition means that the offspring of a hatchery fish that spawned *naturally* (without human intervention) in *natural* (non-hatchery) habitat are categorized as "wild." At the end of the day, what society defines as "wild" is a policy or political call, not a scientific one, but it is important to be clear about which boundaries are used to classify individual salmon as wild or hatchery origin.

From another perspective, some say that the only reason there are *any* "wild" salmon in the Basin is that they (the so-called wild fish) are offspring from hatchery strays that spawned naturally in natural habitat and thus are legally "wild" fish.

Conversely, others claim that most wild runs would flourish *without* hatcheries and reach sufficient levels to support significant fishing pressure. Thus, hatchery operations are a *cause* of the low wild runs, and, therefore, they ought to be closed to allow wild runs to rebound.

Of course, answers to these and similar questions involve some hard scientific "facts," but such questions are far too complicated to answer with traditional scientific experiments and analysis. Modeling might provide a tempting analytical tool, but understanding key ecological/mathematical relationships is limited. Further, the Basin itself has changed in fundamental ways (i.e., dams and substantial changes in land and resource use) in the preceding two centuries. Thus, the opinion of acknowledged experts likely provides the most credible answers to the Basin's most pivotal and complex ecological questions.

Wild Salmon Recovery

No matter how obvious the past may be to salmon experts, starting salmon recovery discussions with a little **historical context** is important. Nearly all salmon runs in California, Oregon, Washington, and Idaho are a shadow of their pre-1850s levels. Further, most of the remaining runs are largely maintained by releases of hatchery-raised fish. *Wild* salmon comprise only a small portion of most runs. Their overall abundance is a sliver of **historical levels**. The few *relatively* abundant current runs are mainly species (i.e., **pink** and **chum** salmon) that spend little time in freshwater before migrating to the sea.

This decline has been known for 150 years, and concerted and substantial efforts have been implemented to recover salmon runs. Especially during the past few decades, the extent and **cost of formal recovery** efforts for *wild* salmon have substantially increased — largely a response to lawsuits filed under the **Endangered Species Act (ESA)**.

Every watershed presents unique features and complications. Further, the species are highly variable, and there are exceptions to almost every biological generality. However, overall, the Columbia River Basin follows the typical downward trend in salmon abundance seen throughout **California**, Oregon, Washington, Idaho, and British Columbia.

While using hatcheries to sustain *relatively* large salmon runs is plausible — although technically challenging — the **requirements of the ESA** relative to *wild* salmon have made the role of hatcheries in maintaining or increasing runs *legally* contentious.

In my interactions with professional colleagues, 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, commercial, and tribal harvests. Arbitrarily, such a level of abundance would need at least a **third of the typical pre-1850s run size** to provide politically adequate fishing opportunities, but would still be far short of historical abundance.

But when technical and scientific judgments go against "conventional wisdom," are scientists likely to be **candid publicly**? Perhaps, when professional scientists can keep their technical and scientific judgments anonymous (and avoid attacks from policy advocates), their "best guess" might be different.

The Thought Experiment

The thought experiment involved identifying 100 nationally and internationally known experts on the **Columbia salmon situation** who have

published widely in peer-reviewed scientific literature. Their extensive scientific publications and other professional activities make these individuals well-known to those who work on salmon issues. All have worked on Columbia River Basin (and elsewhere) salmon issues for decades.

I promised anonymity to all respondents. In the past, working with experts, I was surprised that *even* "big names" are reluctant to be quoted on such important ecological and policy questions. Specifically, when **evaluating salmon issues in the past**, I have been amazed to learn that what experts say in public is sometimes not the same as what they say "off the record." Hence, I guaranteed anonymity to all participants to increase the probability of obtaining more candid responses.

Here is the question sent to each:

> *I hope you are willing to contemplate and answer with an "expert opinion" (i.e., "a guesstimate") about the future of salmon in the Columbia River Basin. Briefly, here is the context for the question . . . after someone watched a recent **Trout Unlimited presentation** of mine, he asked a question that required, on my part, pure speculation to answer. Essentially, the listener asked for my opinion about the role of hatcheries and fishing in controlling the current and future abundance of wild salmon in the Columbia River Basin. I offered him a guesstimate along with the usual caveats and cautions. Still, I am not sure that my answer reflects the thinking of the "scientific community," specifically those most knowledgeable about the issue (that would be you). So . . . let me describe the thought experiment and formulate the precise question.*
>
> *To set the context for this thought experiment (and for some difficult-to-imagine scenario), assume that the U.S. Government decides to immediately and permanently (1) eliminate all releases from hatcheries (i.e., close them all forever) and (2) stop all fishing directly targeting salmon and steelhead. Now . . . allow for time for at least a half dozen generations of completely "wild" spawning (i.e., several generations of fish whose recent ancestors never were in a hatchery). Further, allow for time to pass so that enough years of run size data would somewhat dampen the noise from ocean variations and other climatic factors. So . . . the question . . . after 20-30 years or so of (1) zero hatchery releases; and (2) zero targeted fishing . . . roughly what would be the overall run size in the Columbia Basin compared to current average runs? Stated differently, the question is, 'approximately how many wild salmon and steelhead would the Basin support without salmon fishing and without hatchery releases, and how would that abundance compare to the past several decades and the run levels of the mid-1800s?' Be assured that your response will be entirely anonymous. Because you have spent years immersed in this and similar aspects of salmon management and policy, I look forward to reading your "best guess" answer."*

Although the participants are not listed here, they are all well-known in the world of professional salmon scientists, managers, and policy makers. At least in the salmon world, they are "household names," being professionally active for years. Importantly, I thank them for their candor in answering the question and for trusting me to maintain their anonymity.

Results

The Appendix includes the 58 complete answers reported and discussed here. I reworded (with the author's permission) some initial responses to provide some measure of formatting consistency.

Of the 100 initially identified experts, I could send email requests to 96. Of those, 60 agreed to respond to the question. Two original "acceptors" eventually withdrew their answers because of a concern that the "opposition" or "other side" would use the results to undermine the policy choices that these two individuals strongly supported. In the end, 58 of the 60 responded to the question. Six of the 96 declined to answer the question, typically citing health or other personal reasons. Three others agreed to answer, but never submitted one, even after receiving an email follow-up request. Twenty-nine never acknowledged receiving the initial email request, nor a follow-up request. Invalid email addresses were likely a cause for at least some of these non-responders, especially because some of these individuals were no longer formally employed by fisheries organizations. A summary of the participation rates is presented in Table 1.

As for the other 58 individuals who *did* provide estimates, how much their answers were affected by personal or employer policy preference is unknown. However, based on some policy perspectives expressed in emails, policy preferences likely were a factor in some cases. Most (60%) of the contacted salmon experts participated, probably providing a representative sample of prevailing opinion.

Table 1. *Salmon experts solicited for their opinion on what would happen to overall wild salmon runs in the Columbia River Basin if hatchery stocking and fishing ended.*

Experts sent an initial email request	96	(100%)
Responded with an answer	58	(60%)
Declined to answer question	6	(6%)
Agreed to answer, but did not	3	(3%)
Never responded to initial and follow-up request	29	(30%)

I expected to receive many "back-of-the-envelope" and one-sentence guesses, and this was common, but so were detailed analyses and answers. I was impressed by how many respondents took the time to provide logical backing for their key conclusions. Some wrote pages of detailed analysis justifying every assumption used in answering the question. Others bluntly acknowledged that their answer was a "shot in the dark," and rigorous analysis would not change the reality that the answer provided was an "expert opinion" and nothing more.

As expected with such a general and speculative question, even with light editing (with the author's involvement and permission), there was considerable variation in how each person worded the answer. To simplify analyzing the overall results, I arbitrarily classified each response into one of 5 generic answers (Table 2 and Appendix). Not every prediction was precisely worded, so in those few cases, I used my best judgment after reading the totality of the background submission and then obtained the author's approval of my proposed wording.

Discussion

Table 2 provides a digest of what the experts conclude about whether stopping hatchery releases and fishing will significantly affect the overall wild run size. I assigned each prediction to one of five general responses (see Appendix).

Table 2. Categorization of answers to the question "What Would Happen to Wild Salmon Runs if Hatchery Stocking and Fishing Were Ended in the Columbia River Basin?" with the number (and percentage) of respondents agreeing with each prediction.

A – Predicted wild-only Basin-wide run would be less than the current wild-only Basin-wide run. **22 (38%)**

B – Predicted wild-only Basin-wide run would be roughly equal to the current wild-only Basin-wide run. **11 (19%)**

C – Predicted wild-only Basin-wide run would be greater than the current wild-only Basin-wide run, but less than the current wild plus hatchery overall run. **15 (26%)**

D – Predicted wild-only Basin-wide run would be roughly equal to the current wild plus hatchery Basin-wide overall run. **7 (12%)**

E – Predicted wild-only Basin-wide run would be greater than the current wild plus hatchery Basin-wide overall run. **3 (5%)**

About 57% (A and B) predicted that wild runs would stabilize at the same level (or decrease) without hatchery stocking and fishing. Such a conclusion must be based on the presumption that hatchery releases somehow "support" the so-called "wild" run, perhaps a case of hatchery strays spawning in the wild and their offspring "replenishing" wild runs. Regardless of the reasoning, most experts did not expect any improvement in overall wild salmon abundance.

About 83% (A, B, and C) predicted that current (wild plus hatchery) salmon abundance (overall Columbia Basin run) would decline without hatchery stocking and fishing.

About 43% (C, D, and E) predicted that wild runs would eventually increase, but most of these predictions were for less than the current wild plus hatchery level. The implicit assumption is that either fishing or hatcheries (or both) inhibit wild salmon abundance.

About 5% (E) of the respondents predicted an overall abundance greater than the current total (wild plus hatchery) after salmon fishing was stopped and hatcheries were closed.

Many respondents provided detailed explanations of how they arrived at their bottom line. The debate among scientists about the causal mechanisms will continue for decades, but resolving that debate was beyond the scope of this exercise. What is important here is to tease out a credible, consensus prediction that might provide policy makers with useful scientific input when addressing the unpleasant choices about the future of Columbia River Basin salmon (vs. all the other competing and popular public priorities).

To reinforce a prior explanation about the source of these predictions, who are the experts I selected for this survey? Nearly all were practicing scientists with advanced degrees and publications (not hatchery or fisheries managers). Although only an educated guess, based on my past professional interactions with them, I guess that most probably tend toward the "conservation" side of the salmon policy debate, rather than the "harvest" side.

A final caveat is important to underscore: these scientific predictions are judgments (i.e., **expert opinions**). Presumably, the ones making the scientific judgments are the most knowledgeable about the topic, but these predictions involve assessing complicated scientific issues and will always involve considerable scientific controversy.

More broadly, and perhaps more pertinent here, such information is only one input into fisheries management and policy. For example, how important to society is restoring runs of *wild* salmon to support genetic diversity priorities vs. increasing *hatchery-supported* runs that would sustain higher harvest rates? *Scientific* input is important for settling such tradeoff questions, of course, but it is only one element driving public policy choices (i.e., the **competing values and priorities** that play out during the political process).

Implications

The experts who participated in this thought experiment did not predict that closing hatcheries and stopping fishing are currently key limitations to increasing the abundance of wild salmon in the Columbia River Basin. In addition, based on many narrative comments accompanying the predictions, many participants voluntarily noted that a wild salmon recovery strategy that has any chance of restoring wild runs to anything approaching pre-1850s numbers must address several **overarching and undisputed realities**. They were not arguing that society *ought* to change these constraining realities, just acknowledging that it is unrealistic to expect much change in wild salmon runs without doing so.

So, according to the surveyed experts, if closing hatcheries and stopping fishing do not appear to be the key to restoring wild runs, what is? Regardless, what are these other realities, and how must they be changed to recover *wild* salmon to even a third of their historical level? Let me consider some key ones.

Anyone even moderately familiar with the history of North American West Coast salmon is well aware of the main **causes** of the dire state of salmon runs along the West Coast. These causes are **well documented** scientifically and include fluctuating and long-term climatic and ocean conditions, dams, mining, water pollution, habitat alteration, overfishing, irrigation water withdrawals, predation on salmon by many species (often non-native fish species), and **many other influences**.

Anywhere wild salmon were once plentiful (Europe, Asian Far East, Eastern North America), the decline in their abundance is roughly inversely proportional to the area's **growth in the human population**. Over decades and centuries, as the human population expanded in these regions, the size of salmon runs declined to minuscule levels.

Since the mid-1800s, the West Coast (including the Columbia River Basin) has played out similarly for wild salmon. For example, from a pre-1850 human population level of a few hundred thousand, California, Oregon, Washington, and Idaho are now home to 54 million people. Over the same period, wild salmon abundance in the four States has declined from roughly 50 million to a few million. **And the future**? Assuming expected human population growth in these four States, by 2100, they will be home to somewhere between 150 and 200 million people — a tripling or quadrupling by the end of this century — less than 80 years from now.

For Oregon, Washington, and Idaho, the human population in 2100 would be roughly 40 – 55 million. Even though many of these people will not reside *within* the Basin, they will directly affect the Basin's future. So, what about wild salmon in 2100?

Without dramatic changes in economic policies and lifestyles, **future options** for restoring salmon runs to significant, sustainable levels will be greatly constrained. By 2100, Oregon, Washington, and Idaho will have millions more people, including their *additional* demand for houses, roads, stores, food, coffee shops, air conditioning, drinking water, office buildings, and golf courses — the list is very long.

To illustrate these distasteful **policy tradeoffs** with one well-known example, how does society choose to balance using water to grow food (e.g., irrigation) vs. using the same water to sustain wild salmon?

Returning to the beginning of this article, not surprisingly, many fish species thrive in the highly altered Columbia River Basin. Although unappealing to many salmon *advocates*, perhaps any future analysis should address what is realistically plausible? From a fisheries management and policy perspective, it would surely be easier to maintain sustainable populations of many highly valued *non-native* West Coast fish species (*e.g.*, **American shad**, walleye, bluegill, smallmouth bass, largemouth bass, channel catfish, brown trout, brook trout, and striped bass). Unlike salmon, these species flourish in the even more altered **Sacramento–San Joaquin** River system.

Conversely, perhaps restoring (and even *maintaining*) wild salmon and steelhead runs is so politically popular that nearly any cost or sacrifice is warranted. Such questions are adjudicated in the larger political debates — the events all salmon technocrats read about daily.

In conclusion, based on these survey results, I infer that the current overall abundance of *wild* salmon in the Columbia River Basin (roughly 2-4% of the pre-1850s level) is within the expected range, given the amount and accessibility of high-quality salmon habitat, past and current ecological changes, and overarching trends in oceanic and **climatic conditions**.

Thus, considering the policy implications of the survey results (summarized in Table 2), eliminating hatcheries and fishing is very unlikely to increase the *current* overall total (hatchery and wild) run size. In fact, it is possible (even likely, according to many experts) that current wild salmon runs (wild) would *decrease* from their already low levels.

Policy-wise, perhaps society is prepared to double down and support the governmentally and individually painful choice to restore wild salmon *despite* a warming climate, **greatly altered aquatic habitats**, and opposing demands for flood control, food production, baseload electricity, and other lifestyle desires. Such questions are only partially answerable by scientific and technical experts (such as those I surveyed). Rather, these choices primarily depend on competing, often mutually exclusive, individual and societal priorities. These tradeoffs are wholly unpleasant politically; thus, it should not be surprising that options that would actually recover wild salmon are rarely implemented.

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Appendix

Categorization of responses (58) to the *question "What Would Happen to Wild Salmon Runs if Hatchery Stocking and Fishing Were Ended in the Columbia River Basin?"* with the number (and percentage) of respondents agreeing with each prediction.

A – Predicted wild-only Basin-wide run would be less than the current wild-only Basin-wide run. 22 (38%)

1. *"Current total aggregate Basin run of salmon would drop by roughly 80% with the resulting wild-only runs collectively being less than 1% of pre-1850s runs on average."* A
2. *"When things settle out after closing fishing and eliminating hatcheries, I expect the net effect in the Basin to be a decline in the overall abundance of wild salmon because of diverse other adverse factors."* A
3. *"Stopping all additions of hatchery fish and eliminating all salmon fishing in the Basin, after a couple of decades, will result in a decline in natural-origin fish (i.e., wild salmon and steelhead) compared to the current overall abundance level of wild salmon."* A
4. *"I would expect that most of the small populations in the Snake and Upper Columbia would be extinct or functionally extinct and, for the larger populations elsewhere in the Basin, I would expect that they would be at about 10% of their current abundance and declining towards extinction."* A
5. *"If all salmon fishing and salmon hatchery production in the Columbia was terminated, I would expect salmon remnant runs to survive for a while, but over the following 30 years, climate change will ultimately make the Columbia and the associated marine environment uninhabitable for salmon."* A
6. *"Carrying capacity is the key to answering this question because almost none of the current aquatic environments in the Basin has the same capacity as in the pre-1850s and, therefore, a few decades after closing all hatcheries and stopping all fishing, some of the fully wild runs could be extirpated, and others could be slightly larger than the wild portion of current runs."* A
7. *"Over the following few decades, the current average total of all hatchery and wild salmon and steelhead in the Basin would be reduced 90% from current levels to approximately 1% of the pre-1850s level."* A
8. *"Without salmon fishing and with a total closure of all salmon hatcheries in the Basin and with all other policy drivers remaining in place, the overall total run in the Columbia Basin (wild only) would decrease and end up close to zero after a few decades."* A

9. *"After several decades of fluctuations, after stopping fishing and closing hatcheries, the most likely aggregate Columbia run size of wild adult salmon would be approximately 10-20% of current run size (both hatchery and wild)."* A
10. *". . . the end of hatchery production in the Columbia will lead to the extinction of naturally produced salmon."* A
11. *"My gut response to the bottom line of the question — with no fishing and no hatchery releases — I suspect Columbia River Basin salmon will substantially decline from current wild/hatchery levels, and some local populations would be heading towards extinction."* A
12. *"After several decades of no fishing and no hatcheries, wild salmon and steelhead populations in the Columbia would likely drop to 80% overall of the current aggregate level of wild runs."* A
13. *". . . there would be less than a quarter of the wild salmon in existence today in the Columbia Basin."* A
14. *"Without fishing and hatchery operations, the overall abundance of wild salmon and steelhead would decrease substantially (to about 50%) due to loss of hatchery contributions to overall abundance."* A
15. *"With no fishing and no hatcheries, after 30 years or so, the number of wild salmon and steelhead in the Columbia Basin would be roughly the same as the current overall number of wild salmon and steelhead; that is, it would be substantially smaller than the current total salmon run size."* A
16. *"Even if all remaining harvest fisheries were eliminated and anadromous hatcheries were mothballed, unless the Snake River migration corridor is restored, all wild Snake River stocks (currently < 3% and < 1% of the 1950s - 1960s and pre-1850 abundances, respectively) will very likely be extirpated within 20 - 30 years."* A
17. *"After a few decades of zero salmon fishing and zero hatchery releases, and everything else continuing along, the abundance of wild runs would end up being less than the current wild run abundance."* A
18. *"With wild fish only, chinook, sockeye, and steelhead (and possibly coho) will likely be near extinction or gone from many, if not most areas of the basin, and wild chum and pink salmon runs may continue at or above current levels."* A
19. *"After several decades without salmon fishing and without hatcheries, the overall net effect in the Basin would be a reduction in the current overall wild-only run size."* A
20. *"Even with the complete closure of all salmon fishing and all releases from hatcheries, the long-term downward trend in wild salmon abundance would continue without any other changes."* A
21. *"Even with closing all salmon fishing and eliminating all salmon hatcheries, the current downward trend in wild salmon runs would continue due to environmental degradation and global warming."* A
22. *"After several decades of ecological adjustment, the resulting aggregate runs of wild salmon (and steelhead) would be less than current runs of the wild component of*

salmon/steelhead runs and overall run size would, of course, be much lower than it is currently." A

B – Predicted wild-only Basin-wide run would be roughly equal to the current wild-only Basin-wide run. 11 (19%)

1. *"The current abundance of salmon produced in the Columbia Basin is mostly influenced by coastal ocean carrying capacity."* B
2. *"With the total closure of hatcheries and fishing, over the multiple decade perspective, I expect the change in wild run size to be highly variable, but the overall run size (all wild fish) not to be greatly different than current wild run size, and thus much less than the current total (wild and hatchery) run size, given that habitat does not change."* B
3. *"With no hatchery additions and no fishing, I'm not sure that, even after several decades, there would be much change in wild salmon total numbers in the Basin."* B
4. *"Over the 20-30 yr. period following the cessation of fishing and the closure of hatcheries, the resulting overall level of Columbia Basin wild salmon and steelhead runs would roughly be the same as current wild runs, recognizing that there is a lot of variation in how individual runs would change."* B
5. *"After a few decades without fishing or hatchery stocking in the Columbia, the effects on wild salmon abundance, compared to current levels, will be small."* B
6. *"We will likely not see dramatic changes in wild salmon and steelhead numbers in the Columbia River Basin even if harvest and hatchery production is eliminated, but the number of wild salmon will probably end up slightly higher than it is currently."* B
7. *"Zero change in [wild] adult return rates in the medium to long term."* B
8. *". . . I do not see great increases in run sizes."* B
9. *"I wouldn't expect a hypothetical scenario of zero harvest and zero hatcheries would lead to much, if any, improvement to the current overall abundance of wild salmonids in the Columbia Basin unless additional factors were also addressed (habitat, hydro, climate change)."* B
10. *"After a few decades of adjusting to the removal of hatchery fish and ceasing fishing (and assuming no other changes), the resulting change in the number of wild salmon and steelhead would be small, if any."* B
11. *"If the U.S. Government decides to immediately and permanently (1) eliminate all releases from hatcheries (i.e., close them all forever) and (2) stop all fishing directly targeting salmon and steelhead, then because Snake/Columbia River Basin salmon and steelhead face persistent constraints to recovery due to development and operation of the Columbia River hydrosysytem, we would continue to see overall rapid declines (although variable) for salmon and steelhead in the Columbia/Snake River Basin and the overall decline would be more dramatic for hatchery supplemented Snake River fall Chinook and Sockeye."* B

C – Predicted wild-only Basin-wide run would be greater than the current wild-only run Basin-wide run, but less than the current wild plus hatchery overall run. 15 (26%)

1. *"After several decades, the abundance of wild salmon and steelhead in the Basin would be well below the abundance in the pre-1850's, but also below current levels (wild and hatchery) of abundance."* C
2. *"After all the runs adapt to stopping all harvest and closing all hatcheries, the aggregate run size (salmon and steelhead) would average over the long-term roughly 7% of the historical run size (assuming a pre-1850 average of 10 million)."* C
3. *"Without fishing and hatcheries, Columbia Basin salmon and steelhead would increase 10-15% in total abundance (compared to total wild fish abundance now)."* C
4. *"Cessation of harvest and hatchery production will not lead to a resurgence in the abundance of natural-origin (aka, "wild") salmon/steelhead in the Columbia River Basin, but will result in maybe a doubling (and this could be optimistic) of the current paltry number of wild adult returns — to a number a bit less paltry."* C
5. *"In the absence of hatcheries and fishing, wild salmon would do better than they currently are, but the resulting wild-only abundance would be somewhat less than the current wild/hatchery abundance."* C
6. *"For the Columbia River Basin, eliminating all harvest and hatcheries will likely result in wild-only runs being somewhat higher in abundance than their current low level, thus substantially below the current hatchery-wild total run, and far below the pre-1850 total run, but also more genetically diverse, fit and resilient, thus better able to deal with and adapt to stressors such as climate change."* C
7. *"As for total run abundance in the Basin, given current habitat conditions, I wouldn't be surprised to see wild stocks replace much of the lost hatchery production, but there would surely be bigger Chinook without an ocean fishery."* C
8. *"Three decades after no salmon/steelhead fishing and no salmon/steelhead hatcheries, there would be substantially fewer salmon and steelhead (wild only) present in the Columbia Basin than are currently present (combined wild and hatchery)."* C
9. *"Assuming that only fishing and hatcheries are stopped, but the quality of all other fresh- and saltwater habitats continue on their current trajectories, then there would be about a 10 to 20% increase in natural spawners (wild) in 30 years in the Columbia River Basin."* C
10. *"With no fishing and no hatcheries, the resulting wild-only salmon run in the Columbia Basin would be about twice the current wild-only run, but the current wild run is only a small fraction of the present (wild/hatchery) run."* C
11. *"After several decades without fishing and hatcheries, the overall wild fish run size in the Basin would increase, but, without hatchery salmon, this wild-fish only run would be much less than the current hatchery/wild total, and this resulting*

aggregate wild-only run size also would be lower than the pre-1850s overall salmon abundance in the Basin." C

12. *"The resulting wild run only would be 70% of the current adult [wild/hatchery] return."* C
13. *". . . 1-to-4-fold increase range seems like a reasonable guesstimate [in wild-only overall run size]."* C
14. *"The sustainable population size for a wild fish only scenario (no fishing) generally would be quite small. Overall, the total wild Columbia Basin run would eventually settle out at approximately 5% of the pre-1850s run sizes."* C
15. *"Several decades later, the total run in the Columbia Basin (wild only) would be from 5 times to 10 times the current wild fish only run overall, but less than the current total (wild and hatchery) run."* C

D – Predicted wild-only Basin-wide run would roughly equal the current wild plus hatchery Basin-wide overall run. 7 (12%)

1. *"Without hatcheries and fishing, there would be about the same production as currently exists for combined wild and hatchery fish in the Columbia River Basin."* D
2. *"Given a few decades to adjust, the wild-only aggregate abundance would increase compared to the present aggregate return of wild/hatchery salmon to the Basin."* D
3. *"My best guess for the Basin population response is that (after stopping fishing and closing hatcheries) the total number of returning fish (composed entirely of naturally produced adults) would equal or increase slightly over the present total return (composed of mostly hatchery and some naturally produced adults)."* D
4. *"Under the hypothetical scenario of zero hatchery releases, zero salmon harvest, and everything else continuing, after a few decades, I would predict that many (but perhaps not all) salmonid populations (they would be wild only by then) would level out to roughly 20% of the pre-1850s levels."* D
5. *"With no fishing and no hatcheries and allowing for several decades for adjustment, the collective run size would be about 1-2 million, which is roughly what the total (hatchery and wild) is currently."* D
6. *"Without hatchery supplementation, wild fish runs alone would be about a fifth of the historical size, approximately the current level with both wild and hatchery fish."* D
7. *"After sufficient time for salmon and steelhead runs to adjust to no fishing and the complete elimination of hatchery operations, roughly speaking, total salmon abundance in the Basin would be largely the same, but there likely would be differences in how different species respond."* D

E – Predicted wild-only Basin-wide run would be greater than the current wild plus hatchery Basin-wide overall run. 3 (5%)

1. *"Eventually, salmon and steelhead runs would return to about 20-30% of their pre-1850s abundance with the now totally wild runs fluctuating between about 2,000,000 to 3,500,000."* E
2. *"The remaining wild salmon and steelhead populations would rebuild to the limit of today's Basin habitat capacity, which roughly would result in an all-species total run of 50% of historical run size."* E
3. *"The aggregate run size (wild fish only) in the Basin would rebound to approximately 30% of the pre-1850s run size."* E

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