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Subject: 68 Scientists' letter on the need for lower Snake River dam removal is wrong

TO: Northwest Governors, Members of the US Senate & Congress, Policymakers

I am writing to refute the recent letter signed by 68 scientists stating that Snake River dam removal is required "*to protect and restore abundant salmon and steelhead runs to the Snake/Columbia River Basin*" (22 February, 2021).

Only one of their four claims is correct, namely that "*The actions set forth in the 2020 Federal Environmental Impact Statement (EIS) and Biological Opinion (BiOp) are insufficient and will not reverse salmon declines*". However, my colleagues' call to remove the Snake River dams will not work. It is mathematically impossible for removing the four Snake River dams to materially change salmon survival levels and it is long past time to make this clear to decision makers. Their letter also misrepresents the state of salmon runs in most other regions of the West Coast, which have similar conservation issues. In short, their three conclusions concerning removal of the Snake River dams as a fix for the salmon problems are just plain wrong.

Let me explain.

Snake River Spring Chinook and steelhead currently have a greater than 96% survival rate per dam[i]. These survival levels are the result of major efforts taken by the action agencies and are substantially greater than in the early 1970s when the dams were constructed. They are also roughly on par with survival rates reported from other regions without dams[ii]. As my 68 colleagues correctly informed you, current adult survival levels (SARs) are inadequate to restore Snake River salmon populations to abundance. However, removing the dams will not change this, because the failure of salmon to recover is because of poor ocean survival. Removing the Snake River dams won't fix this.

What the Group of 68 have not said is that it is impossible to achieve the target of 2-6% SARs by making further changes in freshwater. This should have been stated years ago.

[i] Skalski et al (2016). Status after 5 Years of Survival Compliance Testing in the Federal Columbia River Power System (FCRPS). N. Amer. J. Fisheries Management, 36(4), 720-730. doi:10.1080/02755947.2016.1165775

[ii] Welch, D. W., Porter, A. D., & Rechisky, E. L. (2021). A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon. Fish & Fisheries, 22(1):194-211. doi:10.1111/FAF.12514

Consider a simple thought experiment. If you remove all four Lower Snake River dams as requested, it is simple to calculate that SARs will increase from 1.1% to only 1.3%--a barely measurable increase[iii] compared with the needed 4%.

My colleagues, undaunted, will then simply declare that they are still right, but it will require even more heroic efforts to achieve the goals… obviously, the four Columbia mainstem dams must now go as well; surely, taking out the four lower Columbia dams will fix the problem as claimed?

Eight dams are now gone. SARs increased from 1.1% to 1.3% to (now) 1.5%... not even close to the long-promised 4% needed for recovery[iv]. This is the stark mathematical reality that they ignore.

Much of the mortality in the FCRPS is actually due to predators feeding on salmon smolts in the regions between dams, not the dams. Suppose you as the regional decision makers also institute an unprecedented extermination program, wiping out all bird and fish predators and all disease-causing agents contributing to smolt mortality. In effect, you sterilize the river. Average historical smolt survival for the entire 8 dam FCRPS is 53%[v], so eliminating all causes of smolt deaths (8 dams + all predators) moves the SAR from 1.1% to 2.1%—the very lower limit of current recovery targets— but will require major extermination programs that are legally and ethically fraught.

In reality, SARs will hardly budge if you follow my colleagues' plan. Despite their earnest letter, taking out the four Snake River dams won't even come close to achieving what is needed.

Why so little change? My esteemed colleagues will probably assure you that the mysterious "delayed mortality" due to accumulated stresses from the dams will also vanish because the dams are gone, so my simple calculations are too pessimistic. (And they certainly won't mention those extermination programs). However, also unmentioned in their letter, the claims for delayed mortality vanish when broader data sets are considered, which until our recent paper was published[ii] had never been discussed. Evidence for delayed mortality also disappears when adjusting for juvenile salmon size, according to a 2019 NOAA Fisheries study[vi].

The Group of 68's letter simply does not mention the extensive contradictory data because it does not fit with their beliefs. However, a simple calculation shows what level of delayed mortality must be occurring to achieve the 4% recovery target. To get from 2.1% SARs (remember, all dams must be removed and all predators exterminated to achieve this) to 4%, fully 47.5%--***half*** of all Snake River smolts passing Bonneville Dam—must be dying from "delayed mortality"

[iii] Moving from 96% per-project survival to 100% would increase the SAR by a factor of (1/0.96) per dam. This would increase the SAR from 1.1% to 1.1% x $(0.96)^{-4}$=1.3% if all 4 Snake River dams were removed.

[iv] The math is equivalent for removing 8 dams and yields 1.1% x $(0.96)^{-8}$=1.5%. Haeseker (2012) reports slightly lower average historical smolt survival for the entire 8 dam FCRPS of 53%, so eliminating all smolt deaths would move the SAR from 1.1% to 1.1÷0.53=2.1%. This is an overestimate of the gain because it ignores the benefits from more recent improvements in smolt passage. It also requires extermination programs for the entire FCRPS.

[v] Average SAR values from Haeseker et al. (2012). Assessing Freshwater and Marine Environmental Influences on Life-Stage-Specific Survival Rates of Snake River Spring–Summer Chinook Salmon and Steelhead. Transactions of the American Fisheries Society, 141(1):121-138. doi:10.1080/00028487.2011.652009

[vi] Faulkner *et al* (2019). Associations among Fish Length, Dam Passage History, and Survival to Adulthood in Two At-Risk Species of Pacific Salmon. Transactions of the American Fisheries Society, 148(6):1069-1087. doi:10.1002/tafs.10200

caused by those dams. If we "just" take out the 4 Snake River dams, the current demand, ***two-thirds*** of all Snake River smolts passing Bonneville must be dying because of the stress of passing those dams[vii]. This is totally unrealistic.

The ISAB is preparing an evaluation of our published study[ii], so their assessment should be available soon. Unless the ISAB contradict the findings in our paper and conclude that there is real evidence for delayed mortality, the best the region can expect is to get to the lower end of the range (2%)—but only with the help of those major extermination programs that the Group of 68 do not mention. The salmon recovery promised in their letter is impossible, ignores the basic mathematics of the situation, and relies on their personal beliefs instead of the facts.

It gets worse. The Group of 68 go on to note in their letter, *"…the four dams must be removed to not only avoid extinction, but also to restore abundant salmon runs and to achieve the region-wide goals"*. Missing from their confident assertions is any caution about the parlous state of salmon in other river systems. In British Columbia's Fraser River, the largest undammed river on the West Coast, Chinook, sockeye, and steelhead are all in catastrophic decline. For Chinook, only 2 of 15 Fraser populations received "green" status; 11 were assigned a Red status ("…*a conservation unit being considered at risk of extinction*"), one was assigned a Red/Amber status, and one was assigned Amber[viii]. For sockeye, the situation is similar, with the lowest adult returns in over a century occurring in 2019[ix]. None of my colleagues in either the US or Canada can tell you why only two Fraser Chinook and one Fraser sockeye population are doing well when all the other populations are doing extremely poorly, but it clearly can't be because of differences in the number of dams they migrate past, because there are none. Dams certainly aren't the reason the vast majority of Chinook and sockeye populations are in deep trouble. So why should you conclude that the dams are the culprit for the Snake River? Chinook populations in a much broader range of West Coast river systems are in serious trouble[ii], and the Group of 68's arguments clearly won't fix the problems in these other river systems.

For Fraser River steelhead, the situation is even worse: both the Chilcotin and Thompson River populations have tumbled to catastrophically low population numbers over the past few decades, despite having an abundance of pristine habitat and no dams to migrate past[x]. Steelhead in both

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[vii] To see this, consider what fraction of Snake River smolts passing Bonneville Dam must be dying because of the delayed effect of dam passage. Call this proportion *x*. To get from a 2.1% SAR to the target 4% SAR by "fixing" the claimed delayed mortality, the equation is $4\% = \frac{2.1\%}{(1-x)}$. Solving for *x* gives *x*=47.5% (half of all smolts must die due to delayed mortality from the dams). If you remove only the 4 Snake River dams so the SAR rises to 1.3%, the calculation yields 67.5%; two-thirds of all smolts passing Bonneville must die due to these claimed delayed effects. In short, both values are ludicrous, because they require the "delayed" effects in the ocean of the Snake River dams to be as great or greater than direct deaths from all causes occurring in the entire 8-dam FCRPS.

[viii] CSAS (2016). Integrated Biological Status of Southern British Columbia Chinook Salmon Under The Wild Salmon Policy, Canadian Science Advisory Secretariat, Pacific Region Science Advisory Report. 2016/042: 15. http://waves-vagues.dfo-mpo.gc.ca/Library/40595419.pdf

[ix] MacDonald *et al.* (2020). State of the Salmon: Informing the survival of Fraser Sockeye returning in 2020 through life cycle observations, Dept. of Fisheries & Oceans, Government of Canada. Canadian Technical Report of Fisheries and Aquatic Sciences 3398: 76 pp. https://waves-vagues.dfo-mpo.gc.ca/Library/4088546x.pdf

[x] The Chilcotin River is pristine and has freshwater habitat conditions most regions can only dream of. The 2020 population estimate is 38 adult steelhead. For the Thompson River, the estimate is 257 adults. R. Bison, Province of B.C.; personal communication. robert.bison@gov.bc.ca

Fraser River tributaries are requested for emergency listing[xi]. Why, if the Group of 68 are correct and it is the Snake River dams blocking "*the gateway to high quality, resilient spawning habitat*" do we see such catastrophic conditions in these major tributaries of the undammed Fraser River? Why should the reduced marine survival thought to be impeding recovery of Fraser stocks not also apply to the Snake River? Similarly, why should the similar reported SARs of Puget Sound Chinook[xii] and steelhead[ii,xiii,xiv] not also tell us that removing the Snake River dams (and all those predatory populations of birds and fish) cannot possibly be a major factor in the current situation?

The reality is that Chinook populations are in trouble all the way up to the Yukon River in Alaska—despite the pristine freshwater habitat in northern areas that my colleagues are convinced will turn around the fate of Snake River populations if the dams are just removed. They have no explanation for why such problems occur elsewhere, so they simply ignore them.

Early on in our training, the principle of Occam's Razor teaches junior scientists to look for the simplest explanation. Yet too often in salmon conservation this principle is abandoned in favor of complex river-specific narratives that deliberately ignore the parallel declines in salmon abundance in other river systems. In our recent publication we found that rivers without dams or even those with truly pristine freshwater habitat values are suffering the same decline in survival as the Snake River[ii]. Perhaps the most remarkable point is that the generations of salmon biologists running these monitoring programs have not pointed this out. Predictably, the Fish Passage Center labeled our work as incompetent, without ever providing an explanation for why the different agencies performing salmon monitoring work along the West Coast should converge on similar survival values. The Group of 68 in their letter to you also chose to omit any mention of the remarkable similarity in SAR levels that all these agencies are now measuring. The reason is obvious—it doesn't fit with their preconceived ideas.

A Way Forward

The Northwest salmon debate is hardly unique in its shift from science to advocacy. Scientists are people, subject to emotion and opinions. However, to provide true value to society salmon science needs to go back to the basics. Partly this means using the simple calculations I outline to show that the basic claims made are mathematically impossible. However, it also means using the scientific method to rigorously test claims that are still within the realm of possibility. If one has a theory—for example, delayed mortality—then rigorous scientific testing is needed to prove it exists. Mere observation of patterns or correlations, such as better survival of some populations, is not proof of a cause-and-effect relationship and ***always*** need to be rigorously tested—the stakes are simply too high for the region to rely on belief. In fact, willingness to rely on "expert opinion" rather than rigorous hypothesis testing led to the current impasse, where biologists

[xi] Neilson, J., & Taylor, E. (2018). *Emergency assessments of the Steelhead Trout (Oncorhynchus mykiss): Thompson River and Chilcotin River populations (2018).* Government of Canada, Ministry of Environment and Climate Change Retrieved from https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife/special-reports.html

[xii] Sobocinski et al. (2021). A hypothesis-driven statistical approach for identifying ecosystem indicators of coho and Chinook salmon marine survival. Ecological Indicators, 124. doi:10.1016/j.ecolind.2021.107403

[xiii] Welch et al. (2018). The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow-moving catastrophe or deeper failure? *BioRXiv*, 476408. https://www.biorxiv.org/content/10.1101/476408v1.abstract

[xiv] Sobocinski et al. (2020). Ecosystem indicators of marine survival in Puget Sound steelhead trout. Progress in Oceanography, 188, 102419. doi:10.1016/j.pocean.2020.102419

blindly call for evermore efforts in freshwater in the hope that they can somehow compensate for poor marine survival. The belated recognition that many of these past analyses even failed to account for changes in salmon harvest[ii] should be seen as a warning flag that all is not well in salmon science.

A conspicuous element of the Snake River debate surrounds how studies contradicting cherished beliefs are dismissed by opponents as "unrepresentative" without ever showing the claim is actually true. Unfortunately, such claims are commonplace in the Columbia Basin and make your job as policy makers more difficult. Many of the recent claims that analyses contradicting long-held dogma are "unrepresentative" are in fact directly testable using explicit scientific experiments—but currently aren't. These claims need to be tested or the region risks being held hostage by theoretical possibilities rather than proven problems.

Global Warming, Climate Change, and the Future of PNW Salmon

As the four PNW States debate what to do about salmon and the recent call by the Group of 68 to remove the dams, please bear in mind that salmon are not the only resource at risk; so too are hydropower dams as incredibly valuable sources of clean, CO_2-free power.

Dams kill small numbers of salmon in their operations, although much of what is attributed the dams is actually due to salmon predators, and smolt survival in other rivers without dams seems broadly similar[xv,xvi]. A recent paper by NOAA scientists explicitly identifies the ocean as the main cause of future decreased survival due to global warming[xvii]. A UN analysis of plans from 74 countries, accounting for a third of global CO_2 emissions, found those nations' emissions would be reduced by only 0.5% by 2030, compared with 2010 levels[xviii]. However, the Intergovernmental Panel on Climate Change reports that global emissions must fall by about 45% by 2030 to stand a chance of staying below 1.5°C[xix]. The gap is huge.

You and your advisors must balance the direct impacts of hydropower on salmon mortality with the broader goals of identifying a path to a low carbon future. Measured direct impacts of the dams on salmon are now trivial. It is time to say this and recognize that past efforts to correct passage problems have achieved this.

Renewing Salmon Science

The disputes surrounding Snake River salmon now center on differences of opinion as to the underlying causes. Opinion should really count for little. You, as decision makers, should demand

[xv] Welch et al. (2008). Survival of Migrating Salmon Smolts in Large Rivers With and Without Dams. *PLoS Biology, 6*(10), 2101-2108. doi:10.1371/journal.pbio.0060265

[xvi] See Fig. 2. of Welch et al. (2018). The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow-moving catastrophe or deeper failure? BioRXiv, 476408. https://www.biorxiv.org/content/10.1101/476408v1.abstract

[xvii] Crozier, L. G., Burke, B. J., Chasco, B. E., Widener, D. L., & Zabel, R. W. (2021). Climate change threatens Chinook salmon throughout their life cycle. Communications Biology, 4(1), 222. doi:10.1038/s42003-021-01734-w

[xviii] https://www.newscientist.com/article/2269432-we-are-nowhere-near-keeping-warming-below-1-5c-despite-climate-plans/#ixzz6nsnkmYkf

[xix] https://www.ipcc.ch/sr15/chapter/spm/

a higher standard than simply expressions of professional opinion—there is far too much we do not know about the ocean life of salmon to rely on opinion, no matter how educated or sincere the individuals. Biomedical science recently emerged from a similar malaise with the recognition that much of their scientific literature was deeply flawed because of psychological issues surrounding interpretation of data[xx]. The solution in medicine was to ***insist on rigorous double blinded experimental testing of key issues***—not selective interpretation of data supporting a particular viewpoint—coupled with pre-publication of the study plan to avoid cherry picking of the data supporting a particular view. The importance and value of regional hydropower means that you should insist on the same standards for scientific advice you receive.

Difficult Days Ahead

The Pacific Northwest needs to prepare for a much warmer world where salmon populations will likely be reduced to vestigial remnants and, quite probably, regional extinctions. There is much to do. Ignoring this possibility will make the political and legal problems much worse as the climate warms further.

NOAA's recently released study showing massive negative impacts on Snake River salmon from future ocean warming should be a warning bell[xvii]; if future ocean survival should drop as predicted, is it really even advisable to be moving salmon to the ocean more quickly? The Group of 68 are silent on why accelerating salmon to the ocean by dam breaching is even wise, let alone whether it can actually compensate for further reductions in marine survival... and if it cannot, why do it? This question is pertinent because the benefits from decreasing spill at hydropower dams means more carbon-free energy and more flexibility in using the dams to aid in the transition to greater use of wind and solar.

Summary

Your advisors will have told you that relying solely on intermittent power resources (wind, solar) without secure sources of reliable power will likely require three times the capital expenditure otherwise required[xxi]. The required sums are enormous. The Pacific Northwest is fortunate that hydropower dams provide that backstop capacity. The recent calamity in Texas demonstrates the consequences of disrupting reliable sources of power as the climate changes.

I am not an expert on the US power grid. However, I am an expert on the biology of Pacific salmon. I have watched with dismay over three decades as fisheries agencies in both the U.S. and Canada preferentially expanded freshwater monitoring programs that are in reality simply documenting massive decreases in ocean survival without giving much insight into what is going wrong in the ocean. The reasons for this preference for freshwater over marine work are complex and deserving of careful sociological study. However, the end result has left the Pacific northwest exposed to likely catastrophic further declines in Pacific salmon returns caused by poor survival at sea as the oceans warm, with little capability to distinguish between real and imagined impacts of the dams.

[xx] Horton, R. (2015). Offline: What is medicine's 5 sigma? Lancet, 385(9976), 1380. doi:10.1016/S0140-6736(15)60696-1

[xxi] Sepulveda, et. al. (2018). The role of firm low-carbon electricity resources in deep decarbonization of power generation. *Joule, 2*(11), 2403-2420. doi:10.1016/j.joule.2018.08.006

You, as decision makers, have a difficult task—that of balancing competing risks. Snake River salmon are in trouble and there are legal obligations to protect them. The Columbia River Basin dams also need protecting, as sources of reliable CO_2-free power crucial in the pivot away from fossil fuels, which helps slow down climate change—which helps salmon. Operating the dams kills some salmon and brings some gains. My professional advice to you is to balance the risks and rewards but recognize that the claims of my 68 colleagues are impossible.

Regional salmon coordination bodies with complex working groups cannot replace an actual understanding of what is occurring in the ocean. Consider that scientists cannot even tell you with confidence that flushing salmon smolts into the ocean faster will result in smolts having better survival than in the river. That this is not known despite many of my colleagues calling for dam removal to speed smolts into the ocean faster should give you pause— they assume that this it is a good thing without knowing it is true. As so often the case with science, it is the hidden assumptions that can be the fatal flaw in the argument.

I urge you to not get stampeded by panicked calls to do ever-more of what hasn't worked well in the past. The basic mathematics make no sense, even if the objectives are laudable. There may be a need for triage with Snake River salmon —past multi-billion dollar investments have not appreciably changed their SARs compared to other regions along the west coast, so further efforts are unlikely to be more successful.

In closing, there is ample reason to question the diagnosis presented by my 68 colleagues. As the regional decision makers, I urge you to ask your own experts two hard questions: (1) Are the (very) simple mathematical calculations I laid out correct? and (2) Why were the basic issues I raise not acknowledged decades ago rather than simply continuing to focus on the dams as the problem? It is clearly time to develop a more flexible and thoughtful approach to the coming climate changes.

Sincerely,
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Welch's awards and past involvement in identifying the role of ocean climate change on Pacific salmon can be viewed here: http://kintama.com/about-kintama/leadership-team/

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