Supplementary written testimony provided to the Subcommittee on Water, Wildlife and Fisheries, Committee on Natural Resources field hearing in Richland, WA, 26 June 2023 by:

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Chairman Bentz, Representative McMorris Rodgers, and Members of the Committee, thank you for the opportunity to testify before you today regarding salmon and the four lower Snake River dams. I am Dr. David Welch, President of Kintama Research Services, Ltd. Time is short, so I will start by simply stating that I am an expert on Pacific Salmon, and particularly on the ocean phase of their lives, which remains so mysterious to all of us.

I have appended my resume to my written remarks, but I will note here that over my 38 years of professional life working on salmon issues I have received many awards. Amongst those most relevant to your subcommittee's mandate are the 2007 Prix de Distinction from Fisheries & Oceans Canada "*For outstanding scientific contributions related to national and international climate change research*" then in 2008 the Prix d'Excellence from Fisheries & Oceans Canada "*In Recognition of Exceptional Scientific Contributions to the Government of Canada*". I believe that the Prix d'Excellence is Fisheries and Oceans Canada's highest award.

In 2012 I received both the Award of Excellence in Fisheries Management from the American Fisheries Society "*...for inspirational leadership in the fishery profession and substantial achievements for the American Fisheries Society and the fisheries resource*" and the J. P. Tully Medal in Oceanography from the Canadian Society for Meteorology & Oceanography "*...for three decades of research dedicated to understanding the sea life of salmon using innovative data-gathering techniques with special reference to acoustic arrays... This program has provided a core research platform for a wide range of scientists to address questions concerning fish movement and survival*". More recently, in 2022 I was also honored by election as a Foreign Fellow of the Explorers Club in NYC and as an Elected Fellow of the Royal Canadian Geographical Society.

I list these awards because I am going to make some strongly contrarian scientific statements about the science behind Snake River dam removal and it is important for your subcommittee to be able to evaluate my credibility in making these remarks.

The ocean phase of the life history of salmon is fundamental to the issues your subcommittee is now struggling with concerning the role of the Snake River dams in causing the low levels of returning adult salmon. Unfortunately, the ocean has received short shrift by too many of my colleagues, who are looking for things they can do in freshwater to fix, or compensate, for the poor ocean survival of Chinook salmon and steelhead. To understand why I think this approach is unlikely to work and why so many freshwater focused studies get off on the wrong foot, your subcommittee needs to only consider the basic facts of the matter. I will frame these issues very simply for your subcommittee by citing the work of one of the critics of the Snake River dams whose work I much admire, Dr Steve Haeseker of the US Fish and Wildlife Service. Despite our radically different perspectives on the impact of the dams on salmon, I would like to highlight the quality of Dr Haeseker's careful studies. However, I will also use Dr

Haeseker's fine work to illustrate why all of the dams now play such a small role in the poor returns of Snake River salmon from the ocean.

Dr Haeseker's studies show that on average about 53% of young salmon, or smolts, survive the journey down the Snake and Columbia Rivers from Lower Granite Dam to Bonneville Dam. I agree with him. The critics of the dams say that therefore because *"almost half"* of all the salmon die by the time they reach Bonneville Dam, so this is half the salmon problem. They are profoundly wrong. To understand why, let's round average survival in the FCRPS down to 50% to make the numbers simpler to follow. By the time the adults come back from the ocean, survival to adult return, or the "SAR", is 1.1%. Let's make that number 1%. So, now we have ½, or 50%, of the salmon dying from all causes in the FCRPS (dams, predatory birds and fish, and diseases) and just 1/50th of those lucky survivors, or 2%, coming back from the ocean[1]!! That makes the ocean about 25X more powerful in determining the poor adult return to the Snake River.

Please let that sink in, because the enormity of that difference is critical to your understanding of the potential role of the dams in the conservation problem for Snake River salmon. Survival in the lower river and the ocean is only 1/25th the all-cause survival in the FCRPS—dams, predatory birds and fish, and all diseases. Despite this, salmon biologists have persisted for half a century in identifying the Snake River dams as the root cause of the problems and that removing these four dams will magically fix the problems. Yet my high school level use of fractions shows that the critics' own numbers reveal a very different perspective on the cause of the problem, one that is never explicitly laid out as I have just done for you.

Rather than recognize that the direct impact of the dams on salmon survival is now tiny, nearly 25 years ago the theory was put forward that survival in the ocean was bad because of damage inflicted by the dams… so-called "*delayed mortality*". It was a creative idea in its time, because it basically acted like a force multiplier in military parlance; something that made the impact much larger than one would initially expect and essentially arguing that poor marine survival actually had a large component attributable to the dams. In support of this view, the proponents of delayed mortality point to the three times better survival of Yakima and John Day River salmon populations that don't go through the Snake River dams.

Unfortunately, it has been very difficult to get engagement on this basic issue. Back in 2021 a group of 68 biologists wrote to the Pacific northwest Governors, Members of Congress, and Senators essentially saying that *"the time is now to remove the Snake River dams*". Frustrated by the woolly thinking in that letter, I wrote my own rebuttal and sent it to the same group of policy makers the Group of 68 had sent their letter to. Also, as a courtesy, I sent it to those of the 68 biologists whose email addresses I had at hand. Later, I also submitted a version of that rebuttal to the Council on Environmental Quality, or CEQ. (I will submit a copy of this, my supplementary written testimony to the CEQ again). To date, I have not had a single response telling me why I was wrong in my analysis that ***even breaching all eight dams*** would not even come close to achieving the stated policy goal of achieving a 4% SAR.

[1] Just for completeness, let's do the arithmetic with the actual averages: smolt survival through the entire eight dam FCRPS averages at 53% and adult returns average 1.1%. Then survival in the FCRPS is 53% and survival in the lower river below Bonneville Dam until adult return is 1.1/53=2.08%. Using more exact numbers makes no practical difference to the argument. See my response to the "Group of 68" letter for a fuller analysis.

For simplicity, attached to my testimony is my earlier technical response I wrote that examined the claim of the Group of 68 biologists advocating for Snake River dam removal because it was the only feasible way to recover salmon populations to "*abundant and harvestable*" levels.

Several peer-reviewed scientific papers have been published in the past year, essentially supporting the letter written by the Group 68 biologists who in 2021 advocated for Snake River dam removal. All state that removing the lower Snake River dams is the best chance of recovering Snake River salmon populations to *"abundant and harvestable"* levels. I am here to advise you today that that these scientists are wrong, and that the recommendation of my colleagues to remove the Snake River dams to help the Snake River salmon will have only the tiniest of impacts on adult return rates, or "SARs". Actions to breach the dams may in fact very well reduce SARs because past advocacy in favor of dam breaching has consistently failed to consider what happens to the smolts, or young salmon, if they are flushed into the ocean more quickly. Not only do we not know if salmon survival is better in the ocean than what is experienced during downstream migration through the hydropower dams, the studies conducted by both NOAA and the Fish Passage Center's Comparative Survival Study contain logical errors that perpetuate mistakes first made during the studies conducted nearly half a century ago blaming the impact of Snake River dam construction on the demise of Snake River salmon populations.

I understand many within the Columbia River Basin are claiming that the science around dam breaching is "settled" and there is no need for further debate. In contrast to this widely promoted view, I wish to offer today a strongly contrarian testimony. It is my professional opinion that the science of salmon recovery is far from settled, and indeed is riddled with a number of basic errors of logic that the believers in dam breaching have continued to make for over half a century. Unfortunately, these errors—only two of which I will touch upon today—are compounded by an apparently deliberate twisting of the scientific facts that minimize serious known problems with the narrative that is now being promoted. I wish it wasn't so, but I have to state that I believe this conduct is scientifically dishonest. How much is deliberate and how much is simply from a zealous belief that refuses to address the basic problems with various claims about the role of the Snake River dams I cannot say.

Although those in favor of dam breaching do not explicitly state that Snake River dam breach will actually have only tiny impacts on salmon survival, they do argue that in fact that "delayed" mortality caused by the dams reducing survival in the ocean is a major factor. In fact, in a recent scientific review paper by Storch et al. (2022), the group of 12 authors go so far as to state that "*… effects of the hydrosystem can manifest in reduced ocean survival… because of out-migration experiences"*. This paper has had substantial impact on the debate in the Columbia on the role of the dams, no doubt due at least in part to the illustrious reputation of many of the authors, which includes a number of the scientists who originally developed the delayed mortality theory.

Remarkably, despite billing itself as a scientific review paper, the Storch et al paper makes no effort to even acknowledge that the delayed mortality theory was directly tested in a series of peer-reviewed papers by myself and colleagues. The most prominent of these papers was published in the Proceedings of the National Academy of Sciences (Rechisky, Welch et al., 2013). The Proceedings of the US National Academy of Sciences is considered to be one of the top five scientific journals in the world across all disciplines. In our 2013 paper my colleagues and I reported the results from an experiment to directly measure the survival of Yakima and Snake River smolts in the lower Columbia River and north along the west coast of North America all the way to the northern tip of Vancouver Island, some 1,500 kilometers and almost two months after passing out of the hydropower system. The purpose of this breakthrough

scientific paper was to show that survival could be directly measured in the ocean and to explicitly test the theory that *"delayed"* mortality due to Snake River dam passage reduced the survival of Snake River smolts relative to the Yakima population, which had three times higher adult return rates. These much higher return rates are the evidence that proponents of the delayed mortality theory point to when they argue that breaching the Snake River dams will "fix" the Snake River conservation problem.

Despite explicitly testing whether the Yakima R smolts that did not go through the Snake River dams had better survival than the Snake River smolts—the key claim needed to make Snake River dam breaching work—the authors of the Storch et al paper chose to exclude any mention of these studies even though many of the Storch et al authors are well aware of these publications.

The gold standard in scientific research is exactly these sort of treatment-control experiments we conducted over multiple years for Snake River salmon (Rechisky, Welch et al 2013). Yet the Storch et al authors chose to only cite their own highly selective correlation studies that show a higher return rate for Yakima R smolts, which they interpreted as being due to the smolts not migrating through the Snake River dams. So, the Storch et al authors cited their own correlation studies, but refused to even mention to the readers that explicit testing of their theory found no evidence to support their theory. Some "review"!

There is an interesting history here that would have actually made for an informative debate. After our paper was published Dr Steve Haeseker of the FWS, one of the scientists on the other side of the debate who I greatly respect, wrote a critique submitted to the journal arguing that our results might be due to the use of "non-representative" smolts. In essence, Dr Haeseker suggested that perhaps we had obtained the same survival because we had selected smolts from the two populations for the experimental test that were the same size and forced them to migrate to sea at the same time whereas in the normal course of events the smolt size and migration timing might be different. We replied that if Dr Haeseker was correct, then either increasing the size of the smolts or changing the run timing was causing a six-fold increase in Snake River smolt survival for those smolts we hadn't tested, which was more than enough of an improvement to achieve the "abundant and harvestable" standard now being promoted. We also pointed out that even if Dr Haeseker was correct (which was a big "if"!), we had still moved the goal posts because the original version of the delayed mortality theory just claimed that the Snake River dams were bad for all salmon. Now the proponents of dam breaching were arguing that there must be some sort of specialized conditions (small smolts or some subtle difference in migration timing) that were needed to make the theory work.

In any event, a year later we published (in 2014) a further study that removed both of Dr Haeseker's objections and found that the survival of smolts that did or did not migrate through the Snake River dams was essentially the same. As a result, our experimental results say that Snake River dam breach cannot yield the claimed improvements to adult returns.

Storch et al elected ***not to mention any of these issues*** in their review and remained completely silent on the critical point that a direct experimental test of their key claim had been explicitly refuted. This is not science. It is wrong and unless put to rights will deliberately mislead the policy makers who have the difficult job of balancing the competing pressures of our societies. It will also mislead the Tribes, with their deep connection to the land and the salmon, who are essentially being told that supporting dam breach will ensure that their peoples will have abundant and harvestable Chinook salmon.

Yet that belief almost certainly is wrong. In October 2020 we published a paper reviewing all of the government data on smolt to adult return rates, or SAR, of Chinook salmon for the entire coast of North America—from California to SE Alaska (Welch et al 2020). We deliberately chose to be provocative by comparing the survival of all other regions to that for the Snake River. What we found was that for all other regions—including northern British Columbia and SE Alaska, regions with essentially pristine freshwater habitat values and no dams—SARs have now fallen for all regions to be essentially the same as those for the Snake River region. If Alaskan Chinook salmon really do have adult return rates now as low as the Snake River, how are the Tribes going to be assured the "*abundant and harvestable*" Chinook returns that they argue the treaties must provide them with? Clearly, decommissioning the Snake River dams won't provide this because Alaskan natives are also suffering from the same lack of Chinook salmon, despite the absence of any dams.

Storch et al did cite this one paper of ours, but again mischaracterized it. Storch et al cited our paper in one line saying that we "…*suggested that most variation in life-cycle survival can be explained by marine effects common among populations of Chinook Salmon throughout the west coast of North America*". In fact, our message was much more straightforward… we never talked about the variability in salmon returns caused by the ocean, we simply reported that the ***average survival*** was essentially the same everywhere—Snake River dams or no dams! It is the latter issue that is the important policy issue and the Storch et al authors deliberately sidestepped addressing it. Equally serious, in the Welch et al (2020) paper, we showed that much of the data used in the annual CSS study (that many of the Storch et al authors also contribute to) do not support the authors own thesis that Snake River dams are bad for Chinook salmon. For example, we showed that the CSS' own data on Snake River Fall Chinook show that these populations have higher SARs than the SARs of mid-Columbia Fall Chinook that don't migrate through the dams. If dams are the only real cause of these differences in salmon survival, what are policy makers to make of these higher Snake River Fall Chinook survival? Will dam breach actually reduce Snake River Fall Chinook abundances? This seems unlikely, but I raise it to illustrate how selectively blaming the dams for the things that people don't like (bad return numbers) is unlikely to lead to good policy.

Selective citation of just the data fitting one's personal beliefs is unfortunate, but especially so by scientists claiming that dam breaching will fix the salmon conservation problems. Roughly $18 Billion has been spent so far on salmon conservation efforts in the Columbia River Basin with only very modest improvements in the state of the salmon resource. A further $35 Billion to allay the economic harms of dam breach is now being proposed by Rep. Mike Simpson, apparently because of assurances by some in the biological community that dam breach is the only way to improve the salmon resource and honor

treaty obligations to the Tribes. Yet when the Storch et al authors play fast and loose with the facts it is time to call out these bad behaviours.

In fact, I would argue that the Courts have recognized these problems better than regional salmon biologists. Three different federal judges working over nearly 40 years have essentially rejected all of the Biological Opinions on the basis that they were not reasonably likely to address the problem—poor returns from the oceans. In my view the Courts are saying that tinkering with freshwater issues that don't address the bad survival happening somewhere in the ocean after the smolts leave isn't likely to address the real conservation issue—there aren't enough adults coming back from the ocean. I agree with the Courts.

Following my reading of professional declarations to the Court of Judge Simon Mitchell prepared by Ed Bowles, Howard Schaller, and Dave Johnson back in 2021, I was puzzled by why these authors all made the same repeated errors of logic in their claims. When thinking about those Court rulings and then pondering why so many talented salmon biologists consistently ignored the ocean issues in favour of finding something—anything—to work on in freshwater, I decided to go back and read the original studies by the Bureau of Fisheries (NOAA's predecessor) implicating the Snake River dams in the demise of the salmon runs half a century ago (Raymond 1968, 1979, 1988). It turns out that there are severe problems with both Raymond's original studies blaming the demise of Snake River salmon populations on the construction of the dams back in the 1960s & 1970s AND with how subsequent research has built upon those studies. In a word, the research that has been conducted for nearly half a century on the decline of Snake River salmon populations has major, possibly catastrophic, flaws.

Put simply, the Snake River dams probably never caused the major decline in salmon runs that has been claimed for over half a century (certainly not of the magnitude claimed).

I do not make these statements lightly. In the course of my research, I also made what I consider to be several major additional scientific breakthroughs as to why salmon recovery efforts in the Columbia River Basin have been so ineffective. I outlined two (of six) issues in two presentations I gave this past March at a seminar organized on "The Mighty Columbia" on March 3rd and at the Washington-BC meeting of the American Fisheries Society on March 21st. Again, to date I have received no communications refuting my analysis.

In brief, the original studies conducted in the late 1960s and 1970s by Howard Raymond for the Bureau of Fisheries (NOAA) implicating the Snake River dams as the cause of the major decline in survival contain several major errors of logic. These errors do not even require data to demonstrate their fundamental flaws. The key error is surprisingly simple: Raymond (1968) argued that the construction of the Snake River dams would turn the free-flowing river into a series of impoundments, dramatically increasing the migration time of the smolts as they travelled downstream to reach Bonneville Dam, the final dam in the Columbia hydropower system. Raymond argued that this would decrease survival and

apparently all authors since him have agreed with this simple premise; many statements in various annual memos by NOAA and reports by the FPC's CSS make the statement that higher flows reduce travel time and survival of smolts. Yet this conclusion, as simple (and technically correct) as it is, is also highly misleading: measuring survival over a shorter time period means that survival ***has*** to increase!

Consider the case of the roughly 50% smolt survival to Bonneville Dam that Dr Haeseker (and many others) have reported on. If increased flows cut travel time in half and survival increases to 71% most Columbia River biologists would conclude that policy actions leading to increased flows (such as spill) were increasing survival by 21%... a major increase. Yet 71% x 71% is just 50%... no real change. What has actually happened here is that the observation time has been reduced, so fewer smolts die. Only if survival is higher than 71% (which is generally not checked in Columbia River studies) can there be a real improvement in in-river survival to Bonneville Dam. Even more important, survival during the extra time salmon spend in the ocean is completely unaccounted for. Unless survival rates in the ocean are better than in the hydropower system there can be no benefit from increased flow. Despite the elementary nature of these issues, they are almost never factored into statements about how increased flow improve smolt survival. That such a fundamental issue should be overlooked in the Columbia is a very troubling issue and suggests that biologists are not thinking about the issues carefully enough.

A second troubling example of insufficiently critical thinking in Columbia River salmon conservation work concerns the Fish Passage Center's Comparative Salmon Survival Study. This is an important report with multi-agency input that annually reports on smolt to adult (SAR) survival trends using PIT tags and evaluates how the dams influence survival. In October 2020 we published our findings that SARs were very similar coastwide and not materially different from Snake River values (Welch et al 2020). However, in that paper we also reported on our comparison of survival estimates using PIT tags with CWT (coded wire tags), which are occasionally used in the Columbia to measure survival and nearly always used elsewhere for this purpose. PIT tags are considered "*the gold standard*" in the Columbia Basin because an essentially perfect count of the returning adults is possible at the dams. Amazingly, despite their use for over two decades in the annual CSS Reports, we discovered in our work that the commercial and sport catch of salmon is not surveyed for PIT tags and that the unaccounted for harvest rates in salmon fisheries are large and varying over the years, not small (around 1%) as had been assumed by the CSS authors. Making things even more serious, tribal fish catch above Bonneville Dam needs to be added to the catches we reported on. The Boldt decision allocating half of harvest to Tribal Fisheries suggests that for many populations the impact of the missing harvest may be twice as large as we documented for (at least) Spring Chinook.

We were kind to the Fish Passage Center and the CSS report, and reported these flaws in our paper but did not pillory anyone for this error—I strongly believe that science progresses when errors are identified. Yet in the two years and eight months since the publication of our report, there seems to be zero effort made to address these problems with using PIT tags—the CSS annual reports make no mention of the issue, despite the ISRB politely reminding them of the issue in their review of the 2021 report. In point of fact, the failure to incorporate salmon catches into the survival estimates could be catastrophic for efforts to interpret how the dams are actually affecting salmon returns using PIT tags, because salmon managers actively manipulate harvest rates based on what they think ocean survival will

be like. Despite gently pointing this out in our 2020 paper, apparently no attempt has been made to evaluate whether the missing catch invalidates the recommendations in these annual CSS reports. (We published a simple explainer of these issues for policy makers to accompany the publication of our 2020 paper, which can be reviewed here: **Summary for Policy Makers-Animation:** https://youtu.be/FN7yp3FefB8 **; Text:**https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf).

Mistakes happen. However, in science we correct our mistakes. So far as I am aware, there has been no effort made to correct PIT tag-based SAR estimates for the missing catch, **despite the CSS annual reports forming much of the policy basis used to argue for breaching the Snake River dams. In a similar vein, these same reports fail to address the very elementary point that without correcting for the time taken to reach Bonneville Dam, the generally higher survival reported in years of high flow or high spill may simply reflect the fact that survival is measured over a shorter period of time in those years. In summary, I find it frankly shocking that major issues like these remain unidentified and frankly un-addressed even when pointed out. This behaviour biases the policy debate around the role of the Snake River dams. So my final comment to you as policy makers is that if I am correct, the science around Snake River dam breaching is far from "settled".**

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Welch, D. W., A. D. Porter and E. L. Rechisky (2020). "A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (*Oncorhynchus tshawytscha*, Salmonidae)." Fish and Fisheries **22**(1): 194-211 DOI: 10.1111/faf.12514.

DAVID WARREN WELCH, B.Sc., Ph.D. **CURRICULUM VITAE**

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Current Position

President & CEO, Kintama Research Services

Responsible for the development of a technical strategy for building a continental scale acoustic tracking array to serve the needs of the marine science community. The purpose of the array is to put in place a permanent seabed telecommunications network for continental shelf regions of the Eastern North Pacific, and to extend the technology to shelf regions across the globe. Among other goals, the array is intended to facilitate the tracking of individual marine animals (especially salmon) greater than about 10 cm in length and measure survival *in situ*. In a follow-on phase, it is intended for this architecture to also host a wide range of physical oceanographic instrumentation, leading to an integrated ocean observing system that includes the fish tracking sensors.

I founded Kintama to develop the research and design the technological infrastructure necessary to test the array concept and then to create operational arrays. The last two decades of work validated the fundamental engineering concepts underlying the pilot-phase arrays and demonstrated that the scientific results stemming from these relatively simple designs could lead to substantive scientific breakthroughs in fisheries science that could justify the economic costs incurred in their construction and operation.

Background

DATE OF BIRTH:	10 November 1955**.**
CITIZENSHIP:	Canadian.
LANGUAGES:	Fluent in English & Japanese.

Professional Affiliations

AMERICAN FISHERIES SOCIETY
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
THE OCEANOGRAPHY SOCIETY
MARINE TECHNOLOGY SOCIETY

Education

UNIVERSITY OF TORONTO *B.Sc., Biology & Economics, 1977*
DALHOUSIE UNIVERSITY *Ph.D., Oceanography, 1985.*

Areas of Expertise

Biological and Fisheries Oceanography; Marine Telemetry Array Design;

Mathematical Population Dynamics; Operations Research; Statistical Analysis; Economics and Management of Natural Resources.

AWARDS & RECOGNITION (SELECTED HIGHLIGHTS)

2016 ♦ ***Invited* Reviewer**. DFO Canadian Science Advisory Secretariat (CSAS) peer-review process on the risk to Fraser River sockeye salmon due to Infectious Hematopoietic Necrosis Virus (IHNV) transfer from Atlantic salmon farms. *Vancouver, Canada. 4-9 December 2016.*

2015 ♦ **Invited Keynote Lecture.** *"Critical Periods in the Marine Life History of Pacific Salmon"* NPAFC International Symposium on Pacific Salmon and Steelhead Production in a Changing Climate: Past, Present, and Future. Kobe, Japan. 17 May 2015.

♦ **Best Paper Award, 2014.** Most read paper published in the American Fisheries Society Journal *"Marine and Coastal Fisheries"* in 2014.

2013 ♦ **Invited Plenary Lecture**. *"Salmon in Hot Water—Should Current Conservation Approaches be Revisited?"* Annual General Meeting, Washington-BC Chapter, American Fisheries Society. Lake Chelan, Washington. 26 March 2013.

2012 ♦ **Award of Excellence—Fisheries Management.** American Fisheries Society. Minneapolis, Minnesota,19 August 2012. "*...for inspirational leadership in the fishery profession and substantial achievements for AFS and the fisheries resource*". Minneapolis, Minnesota, 19 August 2012. http://www.sdafs.org/fmsafs/stuff/awarexc.htm

♦ **J. P. Tully Medal in Oceanography**. Canadian Society for Meteorology & Oceanography. *"...for three decades of research dedicated to understanding the sea life of salmon using innovative data-gathering techniques with special reference to acoustic arrays... This program has provided a core research platform for a wide range of scientists to address questions concerning fish movement and survival".* Montreal, Quebec, 31 May 2012. http://cmos.ca/Prizewinners/prizewinners2011.html

♦ **Editorial Board,** Journal of Biosensors and Bioelectronics.

♦ **Editorial Board,** Journal of Animal Biotelemetry.

♦ **Member, NOPP (National Oceanographic Partnerships Program) Review Panel.** Gulf of Mexico Research Initiative, Panel 4 (Technology) 16-18 May, 2012, Washington D.C.

2010-11 ♦ **Cohen Commission of Judicial Inquiry.** Expert Witness. 25 October 2010 & 6-8 July 2011.

2009 ♦ **Mid-Island Science, Technology, & Innovation Council. Environmental Technology Award 2009.** *(To Kintama Research).* 5 November 2009.

♦ **Vancouver Island Economic Developers Award.** *(To Kintama Research).* **"For Outstanding Achievement in Economic Development within the Vancouver Island/Coast Region".** 16 April 2009.

2008 ♦ **Prix d'Excellence,** Fisheries & Oceans Canada. In Recognition of Exceptional Scientific Contributions to the Government of Canada. June 2008.

♦ **Plenary Keynote Lecture.** *"The Pacific Ocean Salmon Tracking Array (POST): Challenges in Building Continental-Scale Marine Telecommunication Infrastructures, and Applications to Arctic Climate Research"* MTS/IEEE Oceans 2008 Conference. Quebec City, Canada. September 2008.

2007 ♦ **Prix de Distinction,** Fisheries & Oceans Canada. For outstanding scientific contributions related to national and international climate change research. December 2007

♦ **Invited Keynote Lecture.** *"Technological Innovation in Marine Science: The role of the Pacific Ocean Salmon Tracking Array (POST) in Changing Fisheries Management and Marine Research"* MTS/IEEE Oceans 2007 Conference. October 2007.

PATENTS US 8,444,345 B2 (21 May 2013), Canadian Patent No. 2,690,681 (8 July 2014)-*Floatation Collar for Protecting and Positioning a Sensor Package.*

SELECTED PUBLICATIONS (301 TOTAL) ***Peer-Reviewed:115; In-Review:3; Secondary: 183***

Welch, D.W., Porter, A.D., & Rechisky, E.L. (*2020*). "*A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha, Salmonidae)".* Fish & Fisheries 00:1-18 doi: 10.1111/FAF.12514
Summary for Policy Makers- Animation: https://youtu.be/FN7yp3FefB8
Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

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17 March 2021

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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