AN UNFINISHED STORY

Managed Annihilation of Wild Pacific Salmon

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"Who hears the fishes when they cry?"

Henry David Thoreau

Summary

It started with a good intention: to provide Americans cheap wholesome food from the nation's rivers, estuaries and marine waters. In the closing decades of the nineteenth century, Spencer Fullerton Baird, the newly appointed Commissioner of Fisheries, believed he could easily achieve that goal. To ensure a continuous supply of Pacific salmon, all he had to do was simplify wild salmon's production system much like agriculture simplified the production of corn and other monocultures. Simplification would be achieved by using facilities run with the efficiency of factories (hatcheries). From the beginning, artificial propagation of salmon was tied to an agricultural/industrial model.[1] In addition to the laudable goal, hatcheries had a dark side. They were and continue to be a substitute for conservation and a significant part of the managed annihilation of wild Pacific salmon.

In their role as substitutes for conservation, hatcheries were chosen to mitigate the effects of dams and other habitat degrading activities. The word mitigation was used as a softer way to describe the trade of habitat for hatcheries. The trade of wild salmon habitat for

[a] The title was inspired by Dean Bavington's book *Managed Annihilation: An Unnatural History of the Newfoundland Cod Collapse*.

hatcheries confirmed the hatchery's role as a substitute for conservation and was part of managed annihilation of wild salmon and steelhead. It's a fool's bet to believe that salmon domesticated in the hatchery are our best hope for taking the species through climate change. Neil Evernden gave us part of the reason it's a fool's bet when he stated that "the domesticated animal is a creature stranded in a foreign world, a world of which it can never 'make sense'."[2]

Eighty years ago, Stanford University Professor Willis Rich told us we need to make the individual salmon population the unit to be treated in our management.[3] Salmon managers did not take his advice. Instead salmon populations were lumped together into management units, which lead directly to mixed stock fisheries. Mixed-stock fisheries made it almost impossible to ensure that adequate numbers of wild salmon and steelhead escaped the fishery and returned to their home streams to spawn. Salmon biologists built a managerial system that prevented the attainment of what I call the first principle of salmon management: ensuring that enough fish from every wild population reached their spawning grounds to fully seed the habitat.

The solution to managed annihilation has existed for some time in the several scientific journals dealing with fisheries. Salmon management has failed to incorporate that knowledge into its programs.[4] Salmon managers have been using a coarse-grained approach rather than a fine-grained approach to salmon conservation. The coarse-grained approach uses management units (aggregates of populations) and mixed stock fisheries as well as a heavy reliance on hatcheries. The fine-grained approach protects the salmon's evolutionary legacy, i.e. the tempo and scale of the many ecological processes and relationships that sustain wild salmon populations.

People ask why I continue to use my time to write about the plight of salmon when I should be enjoying my retirement. I've witnessed the wild salmon's problems and, well, one of my favorite writers, Arundhati Roy, summed it up best:

> *The trouble is that once you see it, you can't unsee it. And once you've seen it, keeping quiet, saying nothing, becomes as political an act as speaking out. There's no innocence. Either way, you're accountable.*[5]

Part 1 – The Problem

This manuscript tells a story. It's a story of how salmon management agencies, thinking they were performing as expected have wreaked havoc on the wild Pacific salmon and

steelhead. It is a story of how a management paradigm built on a myth and implemented by complacent institutions has achieved results diametrically opposed to their mission. I participated in salmon management from inside a state agency. At first, I tried to understand the normal operating philosophy of the agency. When I gained enough experience in my career to understand the miss-match between the problems facing wild salmon and the solutions being implemented, I put up a futile battle against the accumulating weight of bad decisions. The burden of those bad management decisions fell on the backs of wild salmon and steelhead and today, I see the wreckage of what was once one of North America's greatest fisheries. The wreckage is hidden from easy view, but I know it is there. And, other animals such as Orca Whales who have a life history linked to wild salmon feel the results of the wreckage. Right now, in the Northwest, J Pod of the Southern Resident Orca Population are starving, partly because their food source of wild Pacific salmon, especially Chinook salmon, has declined so dramatically.

The fact that the salmon's problems are not easily seen has given the management agencies the opportunity to continue operating under the status quo. However, the resulting dramatic loss of wild salmon is too evident to hide. Failure of the status quo is the only way to characterize the extinction of salmon in 40 percent of their historical range[6] and the listing of 26 salmon and steelhead as Evolutionarily Significant Units under the federal Endangered Species Act.[7] Each Evolutionarily Significant Unit may be comprised of several individual populations.

The story begins in the closing decades of the nineteenth century.

Late in the nineteenth century, critical events began to shape fisheries management with important consequences for wild Pacific salmon. In 1870, the American Fish Culturists' Association was founded and then a few years later, in 1885, it changed its name to the American Fisheries Society (AFS). The first article of the society's new constitution said the "Object shall be… the treatment of all questions regarding fish, of a scientific and economic character."[8] I believe this statement, firmly tied fisheries science to economics and because the Society was originally established as an association on fish culturists it was also tied to fish culture. During that period, fish management programs were being implemented based on artificial propagation rather than wild fish protection. And, economics began playing an important part in fisheries management even to the point of overriding ecological reality.

This statement appeared on the first page of the journal *Transactions of the American Fisheries Society* through at least the 1920s and 30s.

> *To promote the cause of fish culture; to gather and diffuse information bearing upon its practical success and upon all matters relating to the fisheries, to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish.*[9]

I am going to digress from the chronological telling of this story and jump ahead briefly to show that economics still overrules ecology within AFS. In the January 2005 issue of AFS's professional journal, Fisheries Magazine, Brian Czech and Phil Pister introduced a year-long series of papers on the conflict between fisheries and economic growth.[10] They wanted to convince the AFS membership to adopt a policy that clearly stated the conflict. Other conservation organizations which had already adopted similar policy statements included the U.S. Society of Ecological Economics (2003), the North American Section of the Society for Conservation Biology (2004), and the Wildlife Society (2004).[11] Czech and Pister's project raised an important question: Can fisheries and more specifically salmon management shift from a paradigm dominated by economics to one dominated by conservation of wild fish?

To further the discussion of the proposed policy, the AFS sponsored a symposium in 2005, on the connections between economic growth and fish conservation. The symposium began with a presentation by Pister on the proposed policy. The debate following Pister's presentation was spirited.[12] Several economists argued against the need for such a policy.[13] The economists objected to two statements and those objections should have been nonstarters from an ecological perspective. The policy statements were: "Based upon established principles of physics and ecology, there is a limit to economic growth" and "There is increasing evidence that North American economic growth is having negative effects on the long-term ecological and economic welfare of North America and the world."[14] After the debate, the proponents and opponents of a policy statement on economic growth continued the discussion until March 2009 when the AFS Governing Board decided the draft policy would not be presented to the membership.[15] The four year delay in making the decision and the ultimate rejection is clear evidence of the dominance of economics in fisheries policy and a troubling weakness in the fisheries scientific community. Anyone interested in the details of the process should consult the Franzin 2009 paper (in the endnotes) and the papers listed therein. Economic considerations overrode ecological reality and prevented adoption of the policy. Letting economics override questions of harvest regulation, habitat protection and ecological health of rivers is a major component of managed annihilation.

Back to the story. Pacific salmon management was put on the path to failure not by some nefarious plot by polluters or exploiters, but by a man who genuinely believed he was

taking the right steps to increase the abundance of food fishes in the United States.[16] The man was Spencer Fullerton Baird, a trained naturalist and science advocate who, in 1871, was appointed head of the newly created U. S. Commission of Fish and Fisheries. This generated additional events of significance for wild Pacific salmon. Baird was an advocate for the extensive use of fish culture. Within a year of being appointed fish commissioner, he established the first Pacific salmon hatchery on the McCloud River, a tributary to the Sacramento River. Three years later Baird was claiming that the McCloud River hatchery was a great success. He made that claim of success before the first juvenile salmon released from the hatchery returned as adults. He was measuring success by the number of eggs fertilized and the number of fry released, not by the number of adults that returned. Similar faux claims of hatchery success would be repeated many times over the next 150 years. Baird turned out to be wrong in his assumptions about the viability of hatcheries, very wrong.

In 1875, Spencer Baird gave advice to the salmon fishermen and cannery operators in the Columbia River on how to maintain the supply of Pacific salmon. He correctly identified what would cause the Pacific salmon to decline in abundance: overharvest, dams and habitat degradation. Baird was able to identify the causes of decline because he had witnessed the decline of Atlantic salmon on the east coast for the same reasons. He believed that laws designed to prevent over harvest, dams and habitat degradation would be ineffective and unnecessary. Instead of laws, he proposed the following:

> *A still better procedure, however, would be to employ the now well-understood methods of artificial multiplication of fish [Sic] so as to maintain the present numbers indefinitely, and even to increase them…. A small and inexpensive hatching establishment could easily be erected on the Columbia near one of the great spawning grounds and eggs hatched out in any…number.*[17]

In 1885, the year the Fish Culturists Association became the American Fisheries Society, the U. S. Commission of Fish and Fisheries published a policy statement on hatcheries that reflected Baird's earlier advice to Columbia River's fishermen and cannery operators:

> *The policy of the United States Commissioner has been to carry out the idea that it is better to expend a small amount of public money [on hatcheries] in making fish so abundant that they can be caught without restriction, and serve as cheap food for the public at large, rather than to expend a larger amount in preventing people from catching the few that still remain after generations of improvidence."*[18]

Spencer Baird didn't know whether hatcheries would, or could, maintain the salmon abundance of 1875 "indefinitely." In effect, Baird's advice to the fishermen and cannery owners of the lower Columbia river was the first use of hatcheries to mitigate the effects of habitat loss and over harvest. Did hatchery mitigation maintain the 1875 abundance of salmon? No, it didn't even come close. To understand the managers' enthusiasm for fish culture it's important to recognize its close association with the success of agriculture.[19] Agriculture's success was transferred to fish culture before any critical hatchery evaluations took place.[20] Fish culturists believed that increasing the abundance of Pacific salmon would be as easy as growing a field of corn. The record that unfolded during the last 150 years shows that Baird's confidence in artificially propagating salmon to maintain abundance and his spectacular prediction regarding the performance of hatcheries were major blunders and the beginnings of managed annihilation.

Regardless of the reasons why Baird favored hatcheries for Pacific salmon, his advice had tremendous consequences. When you strip away the rhetoric and unsupported assumptions about his predicted success of hatcheries, when you allow economics to override ecological concerns, what is left is this: **Hatcheries were a substitute for conservation.** Hatcheries, it turns out, facilitated the overharvest of wild salmon, the building of dams, and poor habitat protection. Baird didn't foresee that hatcheries would end up being another factor leading to the wild salmon's decline.

The essence of Baird's advice—hatcheries are substitutes for conservation—was quickly grasped by the fishermen and cannery operators in the Columbia River. The following quote is from Dan Bottom's landmark paper, To till the waters: A history of ideas in fisheries conservation.

> *More than 170 fishermen, canneries and industry representatives signed a public letter of protest in the Portland Oregonian (January 22, 1877), flatly stating that the establishment of a hatchery 'is the only protection we want for the future prosperity of this important business…We would respectfully remonstrate against… any law preventing [us]from taking fish from the Columbia River at any particular time or in any particular manner…*[21]

In his study of Baird and the Fish Commission, Dean Allard concluded that Baird "…sincerely considered that he was undertaking a service to his country by increasing the supply of fish."[22] However, Baird also blatantly used fish and eggs from commission hatcheries for political reasons. He distributed them to create goodwill among politicians who voted on his budget and with others who he could call on to support his programs. As Baird explained:

> *Some of our distribution of fish is made not so much for re-production and propagation by the parties [but] as… an obligation to some congressmen and individuals. So long as we can enter the matter as attended to, that is all we insist upon. Of course, if fish were scarce, we could not even afford to waste even a small percentage, but… having an abundance we can afford to throw away a few for political or other reasons.*[23]

When he used hatchery fry and eggs as gifts for political goodwill during budget hearings, he created a conundrum. He would defeat the purpose of the gift, if he evaluated hatcheries and found they were failures. They had to be successful; he couldn't take a chance on a real evaluation. For Pacific salmon hatcheries in the United States, evaluations did not take place until the 1960s, but see the footnote.[b] The 1960s evaluation focused on economics addressing the question: Did the value of the hatchery fish caught equal or exceed the cost of operating the hatcheries? Consistent with the dominance of economics in fisheries, ecological costs were not considered. In the early 2000s, I discovered that Baird's conundrum was still around. I was attending a series of meetings regarding the relicensing of a major dam, during which, a proposal for a hatchery supplementation program was discussed. After the meeting I wrote up an addendum to the supplementation proposal describing an evaluation of the hatchery project and brought it to the next meeting. A lawyer at the meeting said my addendum could not be included because it was not necessary. He said there were several published papers that documented the success of supplementation programs. I asked him to bring those papers to the next meeting. At the next meeting I asked him for the papers. He said, Jim, you know there isn't any; we cannot get funding for the supplementation project if the proposal is so uncertain that it must be evaluated. So, they have to be successful. And so, the myth lives on.

Spencer Baird's advice was based on assumptions, that without further validating evidence became a strong belief and eventually hardened into a myth. The myth had captured salmon management before we knew much about the salmon's biology and the negative

[b] Willis Rich conducted a statistical evaluation of hatcheries in the Columbia River in 1921-1922. He examined the cannery pack and the releases of juvenile chinook salmon from hatcheries. He declared, "it must be concluded, therefore, that there is no evidence obtainable from a study of the statistics of the pack and hatchery output that artificial propagation has been an effective agent in conserving the supply of salmon. The writer wishes again to emphasize the fact that the data here presented do not prove that artificial propagation may not be an efficient measure in salmon conservation. These data prove only that the popular conception, that the maintenance of the pack on the Columbia River is due to hatchery operations, is not justified by the available evidence. Rich, W. 1921-1922. A statistical analysis of the results of the artificial propagation of chinook salmon. Manuscript obtained from the NOAA Northwest Science Center library.

impacts hatcheries imposed on wild salmon and steelhead. Baird's advice is an example of what historian Tony Judt called the intellectual sin of the century. Judt was referring to the twentieth century. Baird showed the nineteenth century was not immune to the same sin. Here is what Judt said:

> *It is one thing to say that I am willing to suffer now for an unknowable but possibly better future. It's quite another to authorize the suffering of others in the name of that same unverifiable hypothesis. This in my view, is the intellectual sin of the century: passing judgment on the fate of others in the name of their future as you see it a future in which you may have no investment, but concerning which you claim exclusive and perfect information.*[24]

Judt's statement describes Baird's outlandish claims and predictions. Those claims brought the Pacific Northwest a future of impoverished wild Pacific salmon that Baird did not live to see. Fishing communities, Native American Tribes, sport and commercial fishermen had to live with and suffer from the consequences of Baird's "perfect information."

As I mentioned earlier, when we did evaluate hatchery programs, in the 1960s, it was through a narrowly defined economic lens.[25] Ecological costs of the hatcheries were ignored. Since hatcheries were a substitute for conservation, ecological concerns were pushed to the background and treated as irrelevant. The lack of ecological costs in hatchery evaluations and the use of hatcheries as a substitute for conservation, allowed salmon managers to trade massive amounts of salmon habitat for fish hatcheries, and is a key activity in managed annihilation. Some of those trades were made before hatcheries achieved the ability to produce juvenile salmon and steelhead that survived to become adults on a consistent basis, which illustrates the power of the myth. The following is an example.

Sixty–seven years after Baird's advice to Oregonians, the hatcheries he called for facilitated plans to develop the Columbia River into a massive hydroelectric and transportation system. The proposed development would convert the river into an economic engine driving the region's economy. These two lines of thought (Baird's myth and the river developers plans) merged on March 6, 1947 when the Secretary of the Interior approved this statement:

> *It is, therefore, the conclusion of all concerned that the overall benefits to the Pacific Northwest from a thorough–going development of the Snake and Columbia are such that the present salmon run must be sacrificed. This means that the Department's efforts should be directed toward ameliorating the impact of this development upon*

the injured interests and not toward a vain attempt to hold still the hands of the clock.[26] [c]

With this statement, the middle and upper Columbia and Snake rivers became a wild salmon sacrifice zone. It was the start of a massive dam-building binge that lasted until the mid 1970s. The plan to ameliorate the effects of the dams on salmon was largely based on the hatchery myth. Claiming that hatcheries would ameliorate the effects of the dams was so false and baseless that it amounted to willful deceit. It's informative to compare how the building of main stem dams was approached in the Columbia and Fraser rivers. In the early 1950s. Salmon managers in those rivers faced the same problem, but they used very different approaches to deal with it.

The Secretary of Interior recognized that his decision would force a financial cost onto the salmon canning industry. He proposed to mitigate the effect of the dams with the Lower Columbia River Fisheries Development Program (LCRFDP).

The program had six elements:

- Removal of migration barriers in lower river tributaries;
- Pollution abatement;
- Screening water diversions;
- Transplant salmon populations from the upper Columbia River to the lower river below Bonneville Dam (This defied ecological logic given what we knew about salmon biology at the time.);
- Expand artificial propagation; and
- Establish salmon refuges in streams below the McNary Dam.[27]

The system of refuges was never brought to fruition. Although the program as originally proposed had useful elements it quickly became mainly a hatchery program. In 1951, 49 percent of the budget went to hatcheries and by 1986, 79 percent of the budget was devoted to hatcheries.[28] Spencer Baird's hatchery myth was firmly embedded in the Columbia River's salmon management and the LCRFDP.

[c] When I was at the National Archives and I came across this quote in the document, I was taken back at first, but then later as I watched the massive exchange of habitat for hatcheries, I came to realize that it was really just business as usual.

Salmon managers responsible for the Columbia River fishery were aware, of Willis Rich's advice that the individual salmon populations in their home streams were the critical basis of salmon management.[29] The shift to "population thinking' had been growing for some time in the fisheries literature, especially in Europe.[30] However, Rich and others advocating the importance of populations were ignored because to acknowledge their work would have called into question the plan to move salmon populations from the upper basin to lower river hatcheries. Fish managers implementing the LCRFDP also wanted to minimize scientific research and focus on action items,[31] which meant building and operating more hatcheries. Science wasn't needed. Willful ignorance was enough to implement managed annihilation.

W. F. Thompson was the director of investigations at the International Pacific Salmon Fisheries Commission (IPSFC), which was created in 1937, to manage sockeye salmon in the Fraser River. He was familiar with Willis Rich's belief that the individual salmon population was the basic management unit. Thompson set out to identify the individual sockeye salmon populations in the Fraser River and manage harvest to achieve adequate escapement to each. The basic philosophy of the IPSFC was to protect wild salmon from dams and other forms of habitat degradation and not trade habitat for hatcheries.[32] Because they were more invested in science, the Fraser River managers decided to investigate how well hatcheries actually performed as a mitigation tool. After an investigation, the resulting report stated: "At the present time artificial propagation in not a proven method of maintaining even small localized stocks of Fraser River sockeye and pink salmon."[33] So, when Moran Dam was proposed for the main stem Fraser River, the people were given a choice: the dam or the salmon, but not both. They chose salmon and Moran Dam was not built. In the Columbia Basin, the people were given the slogan "Power and fish you can have both" (Figure1).

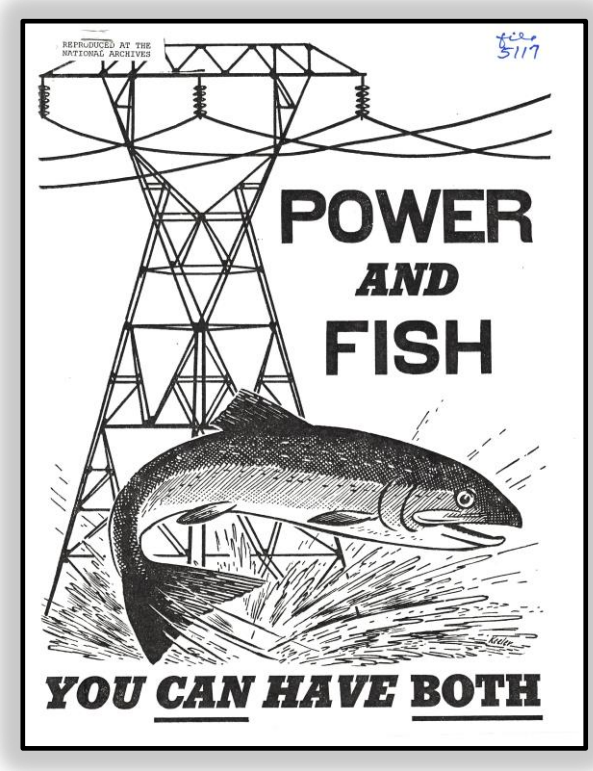

Figure 1. The cover page of a report advocating the construction of dams on the Cowlitz River in Washington State.[34]

The slogan should have been: "Power and fish on the Endangered Species List. You will get both."

Exchanging habitat for hatcheries and calling it mitigation put a softer spin on the reality that hatcheries were a substitute for conservation. There has never been a comprehensive study of the results and ecological cost of hatchery mitigation. How much did we lose or gain by trading habitat for hatcheries? One attempt to evaluate the effectiveness of mitigation with hatcheries that I am aware of was never released to the public.[35] An evaluation of hatchery mitigation raises the question: which attempt at mitigation should be evaluated? For the Columbia River we could ask is it Spencer Baird's promise that hatcheries would mitigate for overharvest and habitat degradation, is it the stated goals of the LCRFDP, the mitigation contracts developed much later or the Northwest Power Planning and Conservation Council's salmon recovery goals. When selecting the evaluation target care must be taken to avoid the problem of shifting baselines.[d]

Earlier, I said that economists argued against AFS adopting a policy that declared economic growth was detrimental to fisheries. The economists were against the policy in part because it contained these two statements:

> *Based upon established principles of physics and ecology, there is a limit to economic growth;* and
>
> *There is increasing evidence that North American economic growth is having negative effects on the long-term ecological and economic welfare of North America and the world.*[36]

For the first statement, most biologists recognize that the biophysical system has limits and economic growth will come up against those limits eventually. Economists have an answer for that – it's called substitutability. When a resource becomes scarce, they believe there will always either be a substitute that occurs naturally or technology will create one.[37] For wild Pacific salmon, technology in the form of hatcheries makes the substitute. But are hatchery fish a real substitute? Environmental philosopher, Eric Katz, would probably say no. According to Katz natural entities like wild salmon can be compared to great works of art. Even a perfect reproduction of a great work of art lacks the "causal genesis."[38] It lacks the creative process that led to the original masterpiece. A natural entity such, as a wild salmon, has intrinsic value because it is the result of the natural ecological processes of the

[d] The problem of shifting baselines is discussed in detail later in this document.

sustaining ecosystem. The hatchery substitute does not have intrinsic value, because it is an artifact of human technology and does not have the same "causal genesis" of wild salmon. Wild salmon can have both intrinsic and instrumental value. Hatcheries produce human artifacts that are commodities with only instrumental value and because hatcheries are a substitute for conservation they contribute to the killing of nature.

For the validity of the second statement what the economists objected to can be demonstrated with two words, climate change. The growth of the industrial economy fueled by fossil fuels is damaging the world's ecosystems and climate change will make that damage magnitudes worse.

So, at the midpoint of the twentieth century the Pacific Northwest was poised to undertake a major technological transformation of the Columbia and other rivers with large dams, a transformation that would have enormous economic benefits (Figure 2). It would also have enormous ecological costs that would imperil wild salmon and steelhead. The regional fishery management agencies would "ameliorate" the danger to wild salmon using a nineteenth century myth, a myth built on a false foundation that included questionable, political manipulation. Hatcheries became the silent partner facilitating both river development and managed annihilation of wild salmon and steelhead. What they produce are not a substitute for wild salmon and steelhead.

Figure 2. Map of dams located in the Columbia River Basin.[39]

In the late 1950s and early 1960s artificially propagated salmon began returning to hatcheries in increasing numbers. Salmon managers believed they had finally solved the problem of maintaining the supply of harvestable fish. Unfortunately, for wild salmon it created another opportunity to ignore conservation and take another step toward managed annihilation.

Prior to 1960, few artificially propagated coho salmon survived to return as an adult to the hatchery that released them.[40] Managers believed prior to 1960, the Oregon Production Index (OPI) was largely made up of wild coho salmon (Figure 3). The OPI is an index of abundance of the aggregate of coho salmon populations from California, Oregon coastal, Columbia River and Southwestern Washington.[41] In 1962, for the first time in 80 years of hatchery operations, they became self-sustaining.[42] Hatcheries no longer had to mine wild coho salmon for eggs. The returns of hatchery fish provided enough eggs to fill the hatchery's capacity. The number of hatchery-origin coho salmon kept increasing. While some biologists recognized that ocean conditions might be playing a role in the abundance of hatchery-origin coho, it was generally believed that improved hatchery practices, better disease control, and more nutritious feed were the primary cause.[43] As the Oregon Fish Commission explained in 1964, "the situation while most encouraging, was not unplanned or unexpected."[44] Hatcheries would now fulfill Spencer Baird's promise and maintain the abundance of salmon beyond natural levels. In reality, instead of a permanent solution to the problem of maintaining salmon abundance, the managers were building a house of cards and a new step in managed annihilation.

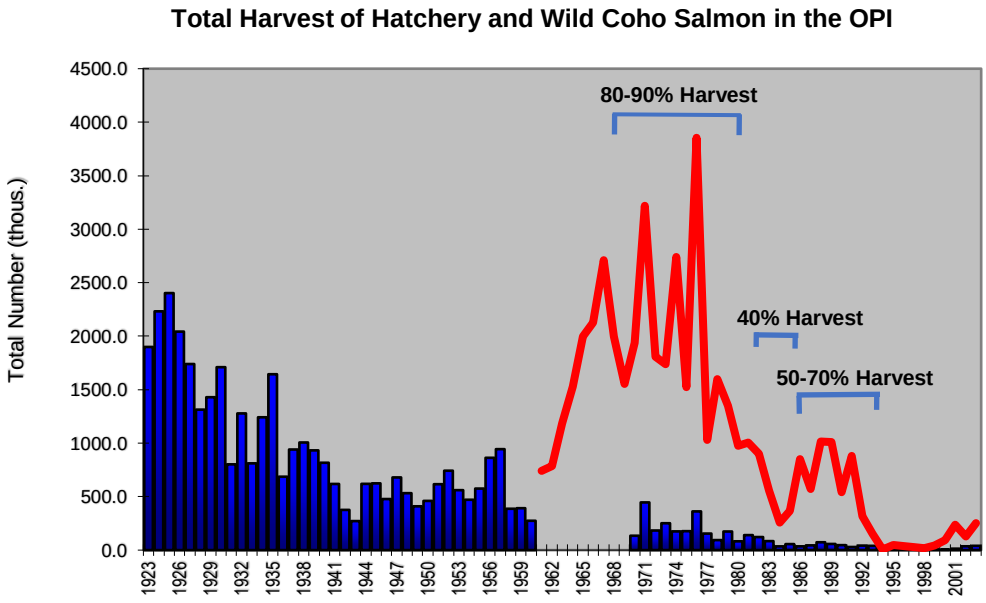

Figure 3. Oregon Production Index (OPI) 1923–2002 showing harvest rates from 1970–1992. (Harvest rates from Pacific Management Council 2003).[45] Red line is hatchery-origin coho salmon and blue is wild coho salmon.

The abundance of coho salmon in the OPI peaked in 1976 at 4.1 million fish. They were nearly all hatchery-origin. The managers let harvest rise to 80 and 90 percent, which overharvested the wild coho in the OPI. This was a clear instance of using the hatchery as a substitute for conservation. It lead to overharvest of wild salmon and a rapid decline in the number of wild coho reaching the spawning grounds.[46] Managers were so confident that hatcheries would sustain the high level of abundance that they allowed the number of commercial fishing licenses to rise from 2,565 in 1960 to 8,566 in 1978.[47] Four million fish was a euphoric level of abundance, but in 1976 the house of cards began to crumble. During 1976, forty ocean variables showed a dramatic stepwise change.[48] The change in the ocean environment caused a collapse in the abundance of hatchery origin coho salmon in the OPI. Harvest dropped from 3.7 million in 1976 to one million in 1977 and in 1997, 28,000 coho were harvested. Because the commercial fleet had grown so dramatically the managers were under pressure to maintain high harvest rates even as the abundance declined toward a listing under the Endangered Species Act, which occurred in 1998 when Oregon's coastal coho were listed as threatened.[49]

Eventually, the cause of the collapse was identified as a change in ocean environmental conditions. Managers used that information to escape blame for the catastrophe following 1977. They claimed that it's the ocean's fault and there was nothing they could do to change or control the ocean. But that wasn't true. Research conducted at the Oregon Department of Fish and Wildlife showed that after the shift in ocean conditions, hatchery-origin coho salmon survived at a much lower rate than their wild cousins.[50] Relying on hatchery-origin salmon and allowing the overharvest of wild salmon was the exact opposite strategy that should have been followed. This story of the OPI coho highlights two key parts of managed annihilation: It shows that hatcheries were still considered a substitute for conservation (in this case rational harvest management and adequate escapement of wild salmon) and that economic concerns (economic value of the catch) overrode ecological reality and drove wild coho salmon to the protection of the Endangered Species Act. Once again economics overruled ecology and wild salmon and steelhead took another hit from managed annihilation.

The question is, which survival story, the one contained in the genes of wild salmon and steelhead or the altered story in the genes of hatchery salmon and steelhead, will be more beneficial to future generations? If the answer is the wild salmon's survival story, the region must quickly change salmon management's status quo.

The OPI story raises the question: Since artificially propagated salmon do not survive environmental change as well as wild salmon, are hatchery-origin salmon and steelhead the fish we should be betting on to survive

environmental fluctuations brought on by climate change? If salmon and steelhead are to have any future after climate change intensifies, it will be the result of a management paradigm that emphasizes healthy wild populations in rivers whose habitats promotes a diversity of life histories. To accomplish that will require a change in the status quo.

The hatchery experience disadvantages salmon when they enter the natural environment. Their survival is lower than their wild counterparts. Part of this lower survival is due to genetic changes that occur when salmon are raised in an artificial environment from spawning to release to the river. Average citizens – including some biologists – are often not familiar with the rapidly changing science of genetics.

Author Richard Powers has condensed the importance of genetics into an easily understandable statement. He was speaking of plants and forests, but the idea is applicable to salmon.

> *At some time over the last 400 million years, some plant [or for our purposes some fish] has tried every strategy with a remote chance of working. We're just beginning to realize how varied a thing working (emphasis added) might be. Life has a way of talking to the future. It's called memory. It's called genes. To solve the future, we must save the past.*[51]

Life tells a story of survival to future generations of trees, wild salmon and all living beings. That story is written in their genes.

The future of salmon depends on the how well the present generation of salmon can talk to future generations of salmon about the lessons acquired during their long evolutionary testing. The best hope for the future of salmon is to save the past, save those priceless lessons. Unfortunately, the hatchery, which is the primary tool of commodity-oriented salmon management, rewrites the story of wild salmon survival acquired through evolutionary trial and error. Adaptation to the hatchery environment occurs rapidly in a single generation. The change can be significant. First generation hatchery steelhead trout showed a difference in the expression of 723 genes compared to wild steelhead.[52]

The question is, which survival story, the one contained in the genes of wild salmon and steelhead or the altered story in the genes of hatchery salmon and steelhead, will be more beneficial to future generations? If the answer is the wild salmon's survival story, the region must quickly change salmon management's status quo.

Unfortunately, this story has more tragic consequences. In order to capture all the economic benefits of the hatchery bonanza, managers raised harvest rates which overharvested wild coho causing a steep decline in spawning escapements in coastal rivers.

Members of the Oregon Legislature looked at this situation and thought they had the answer to the decline in wild escapements. Hatcheries would play a primary role. Because Oregon hatcheries were still receiving more returning adults than they needed to fill their egg requirements, the legislators proposed that the hatcheries take extra eggs from the surplus adults, hatch them, hold them in the hatchery until the fry started feeding then plant the fry into streams with low spawning escapements. In theory this would boost the number of juveniles migrating to sea and increase the escapement of adults back to the streams. Politicians wanted to solve the problem by using Spencer Baird's nineteenth century myth that hatcheries were a substitute for conservation and economic value of the catch was the most important measure of success.

The Department of Fish and Wildlife (ODFW) agreed to undertake the program on one condition: that the legislature fund a thorough evaluation of the results. Fifteen streams were stocked with hatchery fry and 15 unstocked streams served as control streams. The juveniles and adults in each of the streams were monitored from 1980 through 1985. The results are listed below:

- The summer abundance of juvenile coho salmon in the stocked streams was higher than juvenile abundance in the unstocked streams.
- The summer abundance of wild and hatchery origin juvenile coho was monitored separately for two years. During those two years, the abundance of wild juvenile coho in the stocked streams was significantly lower than the unstocked stream. The larger hatchery fry displaced the wild juveniles.
- The adult coho escapement to the stocked and unstocked streams was similar, but the adults that returned to the stocked streams returned earlier than the arrival times of adults in the unstocked streams. [e]
- Despite similar numbers of spawning salmon in the stock and unstocked streams. The subsequent abundance of juvenile salmon was significantly lower in the stocked streams. [53]

The authors of the study "…concluded that the early time of spawning of the hatchery coho salmon was largely responsible for their failure to rebuild the populations in the streams

[e] The earlier time of spawning in hatchery coho salmon was probably due to hatchery practices that selectively obtained eggs from the earliest returning salmon.

stocked with presmolts."[54] The earlier returning hatchery origin adults spawned, but the survival of eggs and fry was lower probably due to early winter freshets. Early spawning hatchery fish were adapted to the hatchery environment but were out of synch with the natural environment. The program not only failed to rebuild the population in the stocked streams it reduced the abundance of wild juvenile coho salmon in those streams.

Hatcheries also lead to the impoverishment of wild coho salmon in the Lower Columbia River. Hatchery practices were linked to a ten-fold reduction in the spawning escapement of wild coho salmon over a 30-year period (1960s-1990s). The detrimental hatchery practices included: Hatchery selection for early spawning as in the OPI story, excessive stocking of fry up to seven times the carrying capacity of a stream, and planting hatchery fry larger than their wild counter parts.[55] Since coho salmon from the Columbia River are part of the OPI, excessive harvest as described in the discussion of the OPI harvest management would have also contributed to the impoverishment of wild coho salmon in the lower Columbia River.

Unfortunately, the example of coho salmon in the OPI has even more lessons relative to managed annihilation. Managers decided to make their job easier by aggregating populations into management units. These units then are given uniform harvest regulations. The OPI is an example of this practice. It included many wild populations of varying productivity and populations of hatchery fish. It didn't matter that the wild populations varied in their productivity because harvest rates reaching 90 percent would overharvest the most productive wild populations. These ocean fisheries on mixed hatchery and wild stocks had devastating effects on wild populations. Here is how W.F. Thompson described the consequence of mixed stock fisheries

> *But we do not know about these independent, sub-specific groups of salmon segregated during spawning, and so we do not know just how to conserve the numerous kinds that exist. In our fisheries, we have been accustomed to dealing with mixtures of many of these units, although each has its own particular requirements… We can only moderate our ruthless fishery, blindly and in partial fashion; we cannot avoid its effect completely. …knowing only that our total catches diminish, as one by one small populations disappear from the greater mixtures which we fish*.[56]

The story of coho salmon in the OPI illustrates the components of managed annihilation. Economics superseded ecological considerations. This led to the overharvest of wild coho salmon in order to maximize the economic return on hatchery programs. Basic principles of conservation such as an adequate spawning escapement were ignored sending the escapement of wild coho salmon into a steep decline. The attempt to use excess hatchery

fry to seed under escaped streams further reduced the abundance of wild coho salmon because the hatchery fish displaced the wild. At the center of these disastrous events was the hatchery and many standard hatchery practices. Hatcheries were clearly the drivers of this episode of managed annihilation.

Another consequence of the mixed stock fishery in the OPI was described by Sam Wright a research scientist at the Washington Department of Fisheries. Wright found that 5,600 kilometers of usable stream habitat in the Lower Columbia River was underutilized.[57]

The management institutions involved in salmon recovery in the Columbia River, were guiding the development and implementation of the Council's restoration program based on a set of assumptions that were out of synch with the current scientific understanding of salmon ecology and their sustaining ecosystems.

Since the 1970s, salmon management has stuck to the myth and its script. At the same time, the literature detailing the negative effects of hatchery programs on wild salmon grew into an impressive weight of evidence.[58]

In the late 1990s and early 2000s I remember talking to hatchery advocates who swore there were no published papers showing anything detrimental about hatcheries. The belief in a myth impedes learning anything contrary to it.[59] Over the years, several independent science panels were convened to review hatchery programs.[60] The science panels came up with many sound recommendations, but there was little, if any real change. The false assumptions about the hatchery production and its ecological cost remain unshaken.

In 1982, the Northwest Power and Conservation Council (Council) tried to rectify the damage created by mainstem dams in the Columbia and Snake rivers. The Council created a massive salmon restoration program. It relied heavily on hatcheries. The Council also established an Independent Science group (ISG)[f] to examine the scientific basis of the program. In 1995, with progress lagging behind expectations the Council asked the ISG to study the scientific foundation of the program. Here is one of ISG's key findings:

> *After reviewing the science behind salmon restoration and the persistent trends of declining abundance of Columbia River salmon, we concluded that the FWP's [the Council's Fish and Wildlife Restoration Program] implied conceptual foundation did*

[f] The ISG was a group of eleven senior scientists and managers assembled to oversee the scientific quality of the Council's recovery program.

not reflect the latest scientific understanding of ecosystem science and salmonid restoration.[61]

The management institutions involved in salmon recovery in the Columbia River, were guiding the development and implementation of the Council's restoration program based on a set of assumptions that were out of synch with the current scientific understanding of salmon ecology and their sustaining ecosystems.

The ISG identified three assumptions that characterized the flawed approach.

The number of adult salmon and steelhead recruited is primarily a positive response to the number of smolts produced. This assumes that human-induced losses of production capacity can be mitigated by actions to increase the number of smolts that reach the ocean, for example, through barging, the use of passage technology at dams, and hatchery production.

Salmon and steelhead production can be maintained or increased by focusing management primarily on in-basin components of the Columbia River. Estuary and ocean conditions are ignored because they are largely uncontrollable.

Salmon species can effectively be managed independently of one another. Management actions designed to protect or restore one species or population will not compromise environmental attributes that form the basis for production by another species or population.[62]

I was a member of the ISG when the study was conducted. At the time I recognized two major deficiencies in those assumptions. They lacked any biological or ecological grounding, and they call for a heavy use of technology to correct problems. Twenty years later, I discovered the most important message contained in those three assumptions. They are an extension of Spencer Baird's hatchery myth into the modern era. No ecology, no biology, no conservation just hatcheries and technology without constraints.

Why has a failed management paradigm persisted?

Before discussing, why a failed salmon management paradigm persists, we need to discuss operational problems within institutions leading to results at odds with their mission. This

information will also help us understand why it will be very difficult to implement the alternative to managed annihilation described in the next section.

It is very unlikely that fish and wildlife commissioners would approve a policy that states: It is the policy of this agency to maintain the status quo even though there is new scientific information that contradicts it. So how is it that we can declare that practices leading to failure persist in salmon management organizations? Professor Emeritus David Bella of Oregon State University has studied organizations and why they fail. He found that organizations systematically distort information in self-serving ways. A natural first response is to ask: Who distorts information, who is responsible? Bella says, "Such distortions do not depend on deliberate falsifications by individuals. Instead, people who are competent, hard-working, and honest can sustain systematic distortions by merely carrying out their organizational roles. Unchecked by outside influences or the undeniable realities of catastrophic failures, organizational systems can sustain self-serving distortions. The potential for catastrophic consequences is significant."[63] The organizational roles Bella referred to are those contained within the conceptual foundation of the organization. For fish and wildlife agencies this is the industrial/agricultural conceptual foundation identified by Gayeski, et al. and confirmed by the ISG in its review of the Columbia River Salmon Recovery Program.[64] Bella also tells us that, "…there are few things that can hide **and sustain a problem** (emphasis added) as well as normalcy."[65] The conceptual foundation of an organization defines normalcy.

George Lakoff, professor of Cognitive Science and Linguistics at the University of California/Berkeley, identified the mechanism of the systematic distortion of information in organizations. He uses the term deep frame as an equivalent to our term conceptual foundation. He says, "…suppose a fact is inconsistent with the frames and metaphors in your brain that define common sense [normalcy]. Then the frame or metaphor will stay, and the fact will be ignored."[66] The conceptual foundation for fish and wildlife management agencies in the Pacific Northwest focuses on the production of commoditized salmon in hatcheries and subjecting them to the maximum possible harvest. Information that challenges that deep frame or conceptual foundation will be ignored which in turn leads to systematic distortion and loss of important information.

This story of wild salmon reminds me of a quote from Richard Powers' book the overstory: *"How could so many smart people have missed the obvious?"*[67] Indeed how could they have missed what was happening to wild salmon and steelhead? Common practices of salmon management agencies and the industrial/agricultural conceptual foundation hid the effects of managed annihilation on wild salmon. Three of those practices are: Shifting baselines, willful ignorance, and goal shifting.

Shifting baselines. The shifting baseline syndrome is a large and growing problem affecting a wide range of natural resources and is global in scale.[68] For this discussion, the focus will be on shifting baselines in fisheries. Historian Jeffery Bolster found evidence of the shifting baseline syndrome as early as 1800 in New England fisheries.[69] Fishery biologist, Daniel Pauly, warned us of the "shifting baseline syndrome" in 1995. He described how fisheries professionals were not aware of the magnitude of the decline in fish harvest and abundance that took place in the twentieth century. Pauly noted that the syndrome occurs when:

> *... each generation of fisheries scientists accepts as a baseline the stock size and species composition that occurred at the beginning of their careers and uses this to evaluate changes. When the next generation starts its career, the stocks have further declined, ...but [now] serve as a new baseline.*[70]

A shifting baseline is the gradual change in accepted norms of wild salmon abundance or the condition of salmon sustaining habitat.[71] They occur, in part, because management agencies lack the knowledge of past abundance of wild salmon and steelhead. They lack that knowledge because as Tim Smith and Daniel Pauly tell us, fisheries managers and scientist generally have shown little interest in the history of their profession and its record.[72]

Marine biologist Callum Roberts examined the decline in abundance of many marine fishes and mammals from the fifteenth century to present, often relying on anecdotal descriptions. He described the importance of historical accounts and the problem of shifting baselines this way:

> *Early accounts of the abundance of fish and wildlife offer us a window to the past that helps reveal the magnitude of subsequent declines. They provide us with benchmarks against which we can compare the condition of today's seas. Such benchmarks are valuable in countering the phenomena of shifting environmental baselines whereby each generation comes to view the environment into which it is born as natural, or normal. Shifting baselines cause a collective societal amnesia in which gradual deterioration of the environment and depletion of wildlife populations pass almost unnoticed.*[73]

Callum Roberts may have given us the reason for the lack of historical perspective in the fisheries profession when he said, "Experience has a bitter taste in fisheries management."[74]

Management baselines are important because they are the benchmarks against which the success or failure of management programs are measured. If the baseline has undergone several decades of downward shifting, then the managers will get a false reading of the results of their programs. They will see success where there is failure and they will see no reason to change the status quo. Shifting baselines give the salmon managers a degree of cover and comfort in the face of failure.

Lowering the baseline allows the salmon manager to falsely claim that modest increases are "record runs" of salmon. This is a major problem because it fools the public into thinking that the current management approach is successful. Shifting baselines hide the magnitude of the real loss of salmon and hides from public view the continuing failure to protect wild salmon. Following is an example: In 2010, the management agencies in Oregon and Washington predicted that the spring Chinook run into the Columbia River would be about 470,000 fish. *The Sunday Oregonian* newspaper claimed that it "could be the largest spring Chinook run on record in the Columbia River."[75] The Northwest Power Planning Council estimated that the historical run of spring Chinook based on maximum peak harvest was 1.7 to 2.3 million fish.[76] Using that number as a surrogate for the historical peak or "record" spring Chinook run, it is clear that 470,000 spring Chinook is not close to a record.

Oregon's Independent Multidisciplinary Science Team summed up the importance of maintaining historical baselines in salmon recovery programs with this statement:

> *The historic range of ecological conditions in the Pacific Northwest, both habitat and of salmon stocks, is important because it provides a framework for developing policy and management plans for the future. The performance of salmonids under historic ecological conditions is evidence that these habitats were compatible with salmon re-production and survival. Land uses resulting in non-historical ecological conditions may support productive salmonid populations, but the evidence for recovery of salmonids under these circumstances is neither extensive nor compelling.*[77]

Managers that are not aware of the wild salmon's historical productivity will falsely believe that the impoverished state of wild salmon is the real baseline. They will believe it is what natural production can be expected to achieve. The managers will conclude that wild salmon cannot be expected to make a significant contribution to the existing fisheries.

Managers often claim that natural production cannot sustain a fishery. This belief persists even though historically, wild salmon sustained harvest levels that have never been equaled by hatcheries. Rick Williams and I characterize this attitude on the part of salmon managers as a loss of "faith in nature."[78] The loss of faith in nature justifies the reliance on hatcheries and reinforces the agricultural/industrial conceptual foundation.

Recent research showing the recovery of a wild coho salmon in Salmon River, an Oregon coastal river, confirms that "faith in nature" is justified. Here is a brief sketch of the study. From 1995 to 2006 a hatchery on Salmon River released about 200,000 coho salmon smolts annually. The wild population declined, and hatchery origin fish accounted for most of the adults returning to the river. Then in 2007 the hatchery program for coho was terminated. Biologists monitored the coho population for seven broods (2006–2013). The result: the abundance of adult, wild coho salmon increased and spawning timing moved from the artificial hatchery timing to more natural timing for the Oregon coast.[79]

Herman Wouk, the renowned novelist of World War II, wrote that, "The beginning of the end of war lies in remembrance." I believe this statement is relevant to more than the end of war. The loss of memory can hide many things in our past that we should not forget lest we repeat them. The loss of memory may also hide things like abundant wild salmon that we should never forget because we will eventually accept the loss without knowing what we are giving up. Shifting baselines rob us of that memory. It sweeps remembrance under a bureaucratic rug, while we are met with smiles and platitudes about how everything is just fine.

Willful ignorance. Willful ignorance can come in two different forms. The first occurs when salmon managers ignore information that would change the status quo. The second is the result of political interference. The first three examples discussed below are of the first kind of willful ignorance and the third example shows the second.

The following paragraph is a repeat from the earlier discussion on page 9 of the Lower Columbia River Fisheries Development Program (LCRFDP). Columbia River salmon managers were aware of Willis Rich's advice that the individual salmon populations in their home streams were the critical basis of salmon management.[80] The shift to "population thinking" had been growing for some time in the fisheries literature, especially in Europe.[81] However, Rich and others advocating the importance of populations were ignored because to acknowledge their work would have questioned the plan to move salmon populations from the upper basin to lower river hatcheries. Fish managers implementing the LCRFDP also wanted to minimize scientific research and focus on action

items, which meant building and operating more hatcheries.[82] Science wasn't needed. Willful ignorance was enough to implement managed annihilation.

We have known since the mid-1970s that hatcheries pose a threat to wild salmon and steelhead. As evidence of the threat accumulated, several independent science panels were convened to examine hatchery operations and their effects.[83] Each of those panels produced several recommendations to improve hatchery practices. Those recommendations were largely ignored. There was no accountability. No insistence that managers incorporate the recommendations into their hatchery programs and report on their success or failure. Willful ignorance remained.

The Northwest Power and Conservation Council adopted its initial Fish and Wildlife Program (FWP) in 1982. It has been amended several times since then. The scope of the FWP and its cost constitutes what may be the largest attempt at ecosystem restoration in the world.[84] Twelve years after implementation of the first FWP, the Council recognized that its plan fell short of an ecosystem approach and that "piecemeal efforts simply have not been effective."[85] In 1994, the FWP underwent a major revision to bring it in line with the latest science. The entire plan was overhauled, but for this discussion, I'm going to focus on one section, Section 7 – "Salmon Production and Habitat," and specifically the subsection, "Ensure Biodiversity." This subsection identified nine measures that the Council wanted salmon managers to implement with funding from BPA:

- Develop a policy to protect wild spawning populations.
- Evaluate salmon survival in the rivers and estuary to understand the ecology and capacity of the basin.
- Adjust hatchery releases to river carrying capacity.
- Collect baseline data on population status and life history of wild populations.
- Conserve genetic diversity.
- Review procedures for conducting population vulnerability analyses.
- Evaluate system wide and cumulative impacts of existing and proposed artificial production projects.
- Establish a biodiversity institute.
- Reprogram existing hatchery stocks and facilities.[86]

These nine measures were key steps in the Council's plan to adopt an ecosystem approach to salmon recovery and bring the FWP in line with the latest science. However, the Council has limited control over which parts of the FWP are implemented. The salmon managers in the Columbia Basin select the measures that they will implement, and mostly, they chose not to implement any of the measures in the biodiversity section of the new plan. Instead,

they chose to focus implementation on hatchery projects. In its review of the suite of projects the fishery managers proposed to implement, the Independent Scientific Review Panel (ISRP) noted that, "There is a noticeable discrepancy between the mix of projects actually funded and the ISRP's interpretation of the intent and priorities of the FWP."[87] The Council's attempt to implement an FWP consistent with the latest science was blocked by the salmon managers. They chose to focus on fish hatcheries. They chose willful ignorance.

Political interference is harder to document, because individuals with knowledge of it will not expose it, to protect their jobs. Fortunately, the members of the Salmon Recovery Scientific Review Panel had the courage to speak out. Here is their story.

After the Oregon coastal coho salmon were listed as threatened in1998, a group of citizens called the Alsea Valley Alliance filed suit in federal court to reverse the decision. The Alliance argued that National Oceanic and Atmospheric Administration (NOAA) should have included the number of hatchery fish returning to coastal streams when determining the coho salmon's status. Federal Judge Michael R. Hogan set aside the ESA listing stating that NOAA Fisheries erred in its decision to exclude hatchery salmon in its status determination. The goal of the lawsuit was clearly to incorporate the hatchery myth into status reviews conducted under the Endangered Species Act. There would be no need to protect habitat as long as the rules governing ESA listings sanctioned the old practice of trading hatchery fish for habitat.[g]

In response to Judge Hogan's ruling, NOAA Fisheries drafted a hatchery policy that defined how artificially propagated fish would be used to assess the status of salmon populations.[88] The policy was reviewed by the Salmon Recovery Scientific Review Panel (SRSRP), a panel of independent scientists convened by NOAA Fisheries. The SRSRP concluded that the policy did not reflect the published scientific research on the difference between artificially propagated and wild salmon and the implication of those differences for management and recovery programs.[89] According to panel members interviewed by the Union for Concerned Scientists, they were told to take those findings out of the report or "see their report end up in a drawer." Sometime later, the flawed hatchery policy was traced to a political appointee in the George W. Bush Administration. This same individual had previously advocated using hatchery salmon to boost the counts of endangered or threatened populations while he worked as a lawyer for the timber industry.[90]

[g] NOAA Fisheries, in response to another lawsuit, re-listed the Oregon coastal coho salmon as threatened.

Goal shifting. This is another tool which managers use to hang onto their failed programs. In a paper addressing the question: "Can fisheries agencies learn from experience?" biologist, Ray Hilborn listed goal shifting as an impediment to learning. Hilborn tells the story of a salmon hatchery that was "totally ineffective at producing adult salmon." The hatchery was scheduled to close, but that generated a huge public outcry. The public believed the closure would show a lack of commitment to the resource. The hatchery stayed open; its goal shifted from producing fish to simply showing a commitment to try to produce fish.[91]

Salmon hatcheries are a substitute for conservation, and they produce commodities or in other words adult fish for the fishery.[92] So, it's logical to expect that the goal and the measure of a hatchery's performance would be the number of adult salmon produced. In 2000, Oregon's Independent Multidisciplinary Science Team (IMST), reviewed an audit of hatchery programs in the Willamette River and the Oregon coast. The IMST found that 41 of 51 salmon and steelhead programs audited, measured performance not by the number of adults produced, but by the number of juveniles released. Only 9 of the 51 programs used adult returns as a measure hatchery performance. The majority, of hatchery programs had their goal shifted from the production of adult salmon to the release of juveniles.[93] If a program cannot achieve its goal, don't admit failure shift the goal to something that looks like success, even if the benefit is hard to describe.

Managed annihilation began with a false idea that hatcheries would be an acceptable substitute for conservation. This paved the way for economics to rule over river development and salmon management especially the production and harvest of commoditized fish. Unfortunately, the false idea was not tested and evaluated until it was too late. By then, it had hardened into a myth. The following quote from former president John F Kennedy points out the danger of myths.

> *For the great enemy of truth is very often not the lie – deliberate, contrived, and dishonest – but the myth – persistent, persuasive, and unrealistic. Too often we hold fast to the clichés of our forebears. We subject all facts to a prefabricated set of interpretations. We enjoy the comfort of opinion without the discomfort of thought*.[94]

So, there it is. We cling to our myths because it is easier, more comfortable than thinking through a problem using facts. Working within the constraints of an institution's myths is easier, but it's like working in an isolated space cut off from the world outside the myth. Those inside the myth can't see the reality outside or hear what the scientist are trying to

tell them. Bill Rees, human ecologist and ecological economist tells us "… that we profess to be a knowledge-based culture – modern society claims to have abandoned myth for the safety of solid science. This itself may well be our greatest cultural myth."[95]

Perhaps the greatest failure in the adherence to the myth is the loss of remembrance. Those few of us that have studied the history of the human-salmon relationship understand that we live amongst the wreckage of what was once one of natures greatest wonders. Yet many even within the fish and wildlife agencies are blind to the destruction. They forget, if they ever really knew, that the huge harvest of salmon and steelhead in the late nineteenth and early twentieth centuries were all wild fish. Today salmon are extinct in 40 percent of their historic range and 26 Evolutionary Significant Units (ESU) are protected under the Federal Endangered Species Act (ESA). When the salmon and steelhead were listed under the Federal ESA I thought the listings would shake out the complacency and force salmon management to abandon the myth. I was wrong. When the three assumptions the ISG identified as the current conceptual foundation of the Columbia River salmon restoration effort are read in the contex of the history of salmon management, its is clear that they are a modern version of Spencer Baird's myth. In keeping with the myth, the National Marine Fisheries Service has decided that ESA protection of listed species will be subsumed into Spencer Baird's hatchery myth.[96]

Part 2 – The Alternative to Managed Annihilation

Why is it important that the focus of management be on the individual salmon and steelhead populations?

The alternative to managed annihilation is known; it exists in information buried in the fisheries literature. Unfortunately, management agencies are slow to incorporate new scientific information into their programs. They have no formal process to ensure the new information is identified and discussed to determine its relevance.[97] The alternative to managed annihilation recognizes that for Pacific salmon the population and its home stream or tributary is the fundamental management unit. This is not a new revelation. In 1939, Willis Rich said that the management focus for Pacific salmon must be on the population.[98] Population thinking began much earlier in Europe with the work of Heincke, Hjort and Schmidt.[99] Here is what Rich said:

> *In the conservation of any natural, biological resources it may, I believe, be considered self-evident that the population must be the unit to be treated. By population I mean an effectively isolated self-perpetuating group of organisms of the same species*

regardless of whether they may or may not display distinguishing characters, and regardless of whether these distinguishing characters, if present, be genetic or environmental in origin. Given a species that is broken up into a number of such isolated groups or populations, it is obvious that the conservation of the species as a whole resolves into the conservation of every one of the component groups…[100]

Using contemporary tagging studies Rich also recognized that the individual populations of salmon migrated long distances from their home stream. He believed this supported the theory that salmon homed back to their natal stream to spawn, but it also introduced another problem in their conservation.

….The fact that Columbia River Chinook salmon are to be found off the coasts of southeastern Alaska and British Columbia during their oceanic migrations is of greatest importance to an understanding of the causes affecting the abundance of these fish. It is of importance because, in these northern waters, the fish are subjected to an intensive fishery carried on by hook and line in the ocean and the development of this fishery has undoubtedly increased the rate of mortality although a measure of the effect has not, and perhaps cannot be secured. Only through knowledge of the migrations of these fish could we know the drain that such distant fisheries make on the particular runs. [101]

The mixed-stock fisheries in Alaska and British Columbia are still a problem.

Rich's paper is important. He was working with rudimentary information that nevertheless gave him the beginnings of an ecological approach to the management of Pacific salmon. He stressed conservation and not the hatchery substitutes for it. He was giving us an alternative to management dominated by economics and a factory-like hatchery operation. Although, salmon managers ignored his recommendation, fishery science kept adding to the ecological understanding of wild salmon survival and productivity. The following paragraph from a 2011 paper by Dan Bottom and his colleagues gives us some insight as to how Rich's rudimentary ideas have been enhanced by science.

The spatial structure of salmon populations and the varied ocean migration patterns of individual salmon stocks create and additional ecological complexity that does not map neatly onto existing management jurisdictions or the scales of ocean fisheries. Because salmon return to their natal stream to spawn, populations adapt to local watershed conditions creating a geographic matrix of uniquely and self-perpetuating populations within species. Salmon homing behavior and local adaptations argue for a fine-grained management approach that recognizes the individual population and its

> *associated watershed as a fundamental conservation unit (Rich 1939, Lichatowich 1999). Yet, despite improved genetic discrimination and other technological advances, the resolution of fisheries management remains relatively coarse, unable to discriminate the population and stream-specific origin of individual salmon harvested at sea*.[102]

The operative words in Bottom's paragraph are coarse-grained (current management) and fine-grained (what management should be).

Compared to other fishes, Atlantic and Pacific salmon are among the most population rich.[103] To understand reason for this population richness, consider what happens when salmon enter a river to spawn. If you could follow salmon after they enter a river, you would see them begin to separate into individual groups. Each group disperses to the same stream reach or tributary where it began life.[104] The local breeding groups, when physically isolated from other groups during spawning, fit the common definition of a population. Reproductive isolation – the return to the same place to spawn generation after generation isolated from other spawning groups – adapts the population to the environmental conditions of its home stream, the hundreds of adaptations on large and small scales. Think of a large, muscular chinook salmon adapted to swim upstream over falls and through high velocity rapids or an inch-long fry hiding in the interstitial spaces of the stream bed picking a mayfly off a rock.

To understand why it's important for salmon management to focus on the individual population, we need to start with the salmon's strong attachment to its natal stream reach or tributary. The salmon's return to the to the same stream to spawn generation after generation imparts a fittedness between salmon and the landscapes they inhabit.[105] It is the well-spring of important attributes of genetic and life history diversity. The individual population and its home stream are what management should be trying to protect and nurture. The fine-grained approach to management also recognizes that:

> *Species [and salmon populations] do not exist in a vacuum, and any [valid] definition of biodiversity must include the ecological complexes in which the organisms naturally occur and the ways in which they interact with one another and their surroundings.*[106]

Barry Lopez tells us that diversity of all kinds is important for fundamental reasons:

> *Diversity is a condition necessary for life. Diversity creates the biological tensioning that makes life in general vigorous and sustainable. It's diversity that ensures perpetuity. The loss of diversity, on the other hand, threatens all life with extinction.*[107]

Salmon management programs guided by the agricultural/industrial conceptual foundation are systematically stripping away diversity:

- Salmon aggregates managed under uniform regulations fail to recognize the diversity in productivity in the individual populations.
- These aggregates lead to mixed-stock fisheries that eliminate the weaker populations and make it impossible to ensure adequate number of adult salmon escape the fishery and reach each population's spawning grounds.
- Hatcheries that operate with factory like efficiency systematically strip the salmon and steelhead of their diversity. To achieve efficiency all the fish must follow the same schedule and process.

These practices must be stopped or severely curtailed because they prevent the transition to a fin-grained management paradigm.

The salmon's attachment to their natal stream is so important that it generates what I call the first principle of salmon management: ensuring that enough fish escape the fishery so that sufficient fish from each population reach the spawning grounds of their home stream in numbers that fully seed the habitat. Achieving this would be the start of a fine-grained approach to management, which is also known as river and population-specific management.

The special importance of life history diversity

River and population specific management must recognize and work with the unique attributes of individual rivers and populations. Each river will have unique attributes and problems that must be considered.

The salmon must pass through and temporarily occupy a chain of habitats to complete their life cycle.[108] The population's movement through this chain is a spatial-temporal pathway through the salmon's extended ecosystem[109] and it defines their life history. A salmon population is not limited to a single life history pathway. W. F. Thompson said a population might be composed of a bundle of several life history-habitat chains.[110] For example, fall Chinook salmon in Sixes River, Oregon, followed five different spatial-temporal pathways through the river's freshwater and estuarine habitats,[111] and Chinook salmon in the Rogue River, Oregon, followed eight pathways.[112] Spring Chinook salmon in the Willamette River followed six primary life histories.[113]

Life history diversity is an important attribute in a salmon population. It buffers the impact of climate variability and natural habitat changes. Some life histories will be favored and some disadvantaged under a given set of environmental conditions. When conditions change, survival values of the population's life histories will also change. This variability in the response of a population's life histories to changing climatic conditions is called response asynchrony. Life history diversity and response asynchrony are how salmon avoid putting all their survival eggs in one basket. It spreads the risk of mortality,[114] and it makes an important contribution to the salmon's resilience in the face of changing environmental conditions.[115]

The advantages of life history diversity extend beyond a single population to multiple populations over a large geographical area. The stability and sustainability of sockeye salmon in western Alaska's Bristol Bay has been attributed to life history diversity among the region's many sockeye salmon populations. Life history diversity spreads the risk of survival causing an asynchronous performance among the sockeye populations – while some populations showed high productivity, others were at low productivity and vice versa under different climatic conditions. That allowed the region to experience stable levels of overall productivity.[116]

Wild salmon management must begin the transition to fine-grained management. Management agencies should adopt a long-term goal to apply river and population specific management to all wild Pacific salmon and steelhead populations in the Pacific Northwest. The survival of wild salmon as climate change progresses will depend on the health, biodiversity and resilience of individual wild salmon populations.
The basic elements of the fine-grained or river and population specific management are:

- Develop escapement targets for the wild populations of each species to achieve egg deposition and smolt production goals. Monitor compliance with those targets.
- Develop and protect a habitat template that supports adult holding and spawning, juvenile rearing, a diversity of life histories and a healthy web of ecological relationships. Monitor life history diversity as an indicator of ecological health of the stream and population.
- Allow no interbreeding between hatchery and wild fish.
- Advocate for native diversity in all its forms throughout all watersheds inhabited by wild salmon.

River and population specific management must recognize and work with the unique attributes of individual rivers and populations. Each river will have unique attributes and problems that must be considered. It is beyond the scope of this manuscript to make

specific recommendations or plans for individual rivers beyond the three general guidelines.

The title of this document says this is an unfinished story. It's unfinished because we cannot answer the questions: will management agencies stop following the path that has brought wild salmon and steelhead to their current impoverishment or will they finally see the wreckage their current management has created and make the needed changes? Will managed annihilation be ended? Will a new generation of biologists take up the cause of the wild salmon and steelhead?

At this point of the unfinished story, I want to summarize the salient issues raised by this manuscript.

1. In the early years of the study of salmon, Spencer Baird offered hatcheries as a substitute for conservation. Those of us who have studied the history of the use of hatcheries in salmon management, know the use of hatcheries does not serve the purposes of conservation.

2. Individual salmon populations thrive based on their healthy ecological relationships and biological makeup. The use of human-defined management units often composed of several populations and mix-stock fisheries create a threat to wild salmon and steelhead and must be eliminated or neutralized. The best approach for management/conservation must focus on the individual salmon populations.

3. Hatcheries are a threat to wild salmon and steelhead conservation. All hatcheries that cannot convincingly demonstrate they are not a threat must be closed. Several sources of hatchery impact on wild populations were mentioned in this manuscript. All impacts must be evaluated to determine, if a hatchery is to remain open.

4. Today the large industrial production system (hatcheries) gives the appearance that something is being done to halt the decline in salmon abundance. It hides the fact that hatcheries have been and continue to be a key component in managed annihilation.

5. The fine-grained approach to salmon and steelhead management will result in additional costs to agencies. Savings from the closure of ineffective hatcheries should be applied to the additional costs associated with fine-grained management.

6. The three assumptions of the current conceptual foundation result from the extension of Baird's hatchery myth into current management planning and implementation. (Shown on page 19.)

7. Shifting baselines rob us of our remembrance of the past and makes us comfortable with the current hatchery myth and its consequences

8. Several independent science panels have reviewed hatchery programs and developed recommendations for improvement. Very little change has occurred because information that is contrary to the hatchery myth is ignored. Salmon managers must begin to use the recommendations of the science panels.

9. Hatchery accountability has been ignored and that must be corrected. First the ecological cost of hatcheries must be included in all cost/benefit analyses of hatchery performance. Second the concept of hatchery mitigation for the effects of dams needs a thorough evaluation. In terms of salmon abundance, how much has hatchery mitigation cost the Pacific Northwest.

10. Hatcheries rob the salmon of their evolutionary legacy – the natural ecological processes and experiences that create the wild salmon's natural-restorative characteristics.

11. American Fisheries Society should take the leadership role and reevaluate its strong ties to fish culture and economics.

12. Current fish and wildlife agencies must act to create a major overhaul of their agency and that action may come from outside the institution.

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