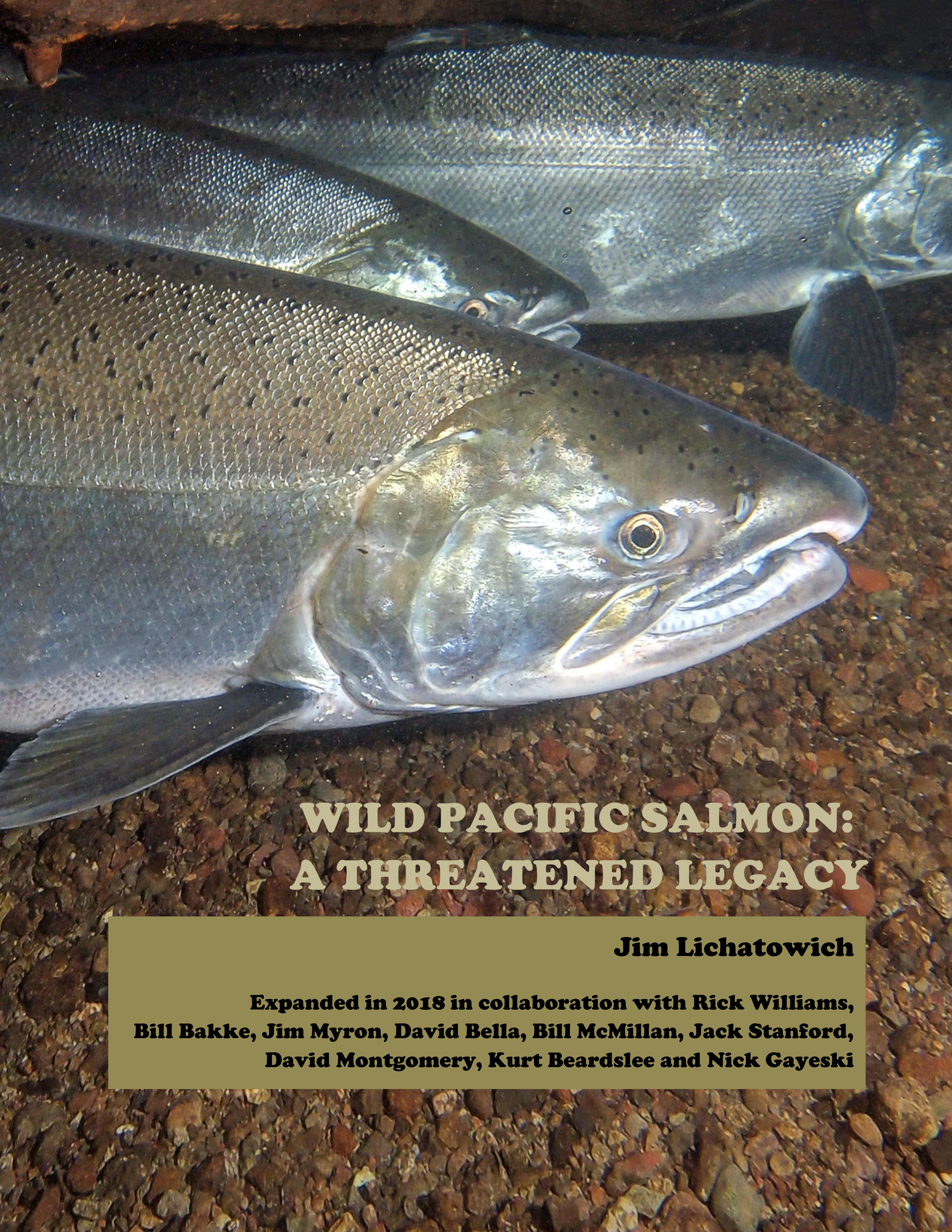

WILD PACIFIC SALMON: A THREATENED LEGACY

Jim Lichatowich

Expanded in 2018 in collaboration with Rick Williams, Bill Bakke, Jim Myron, David Bella, Bill McMillan, Jack Stanford, David Montgomery, Kurt Beardslee and Nick Gayeski

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1- Photo by John R. McMillian. King salmon.

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Prologue

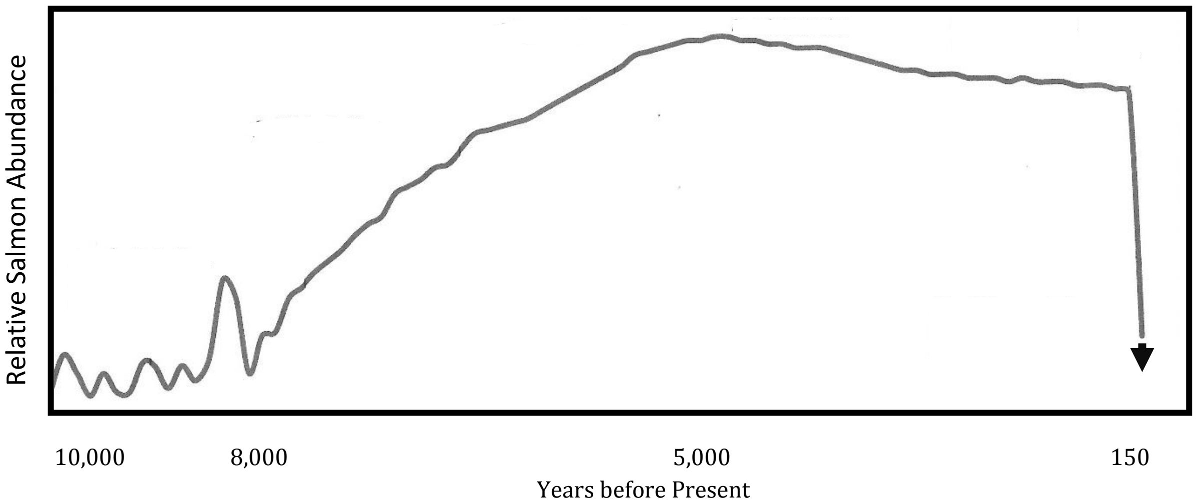
Wild Pacific Salmon's Long History

"But I fervently believe that we need a historical perspective on humanity's last major source of food from the wild. When fish cease to play that role, a significant link with our long history will have been severed."[1]

The family Salmonidae has a long history. It may go back 100 million years.[2] Forty million years ago the earliest confirmed Salmonidae, a fish resembling a modern grayling, left its bones in lake sediments in British Columbia. Fifteen million years ago a six-foot stream-dwelling salmon with large curved breeding teeth known as the sabre tooth salmon inhabited streams in central Oregon and coastal California. The modern salmon have been around for about two million years.[3] While the long evolutionary history of salmon is interesting, we are going to focus our attention on the last ten thousand years of the wild salmon's long history.

As the Cordilleran Ice melted about 10,000 years ago, salmon spread out from ice-free refugia such as the lower Columbia, Sacramento and Chehalis rivers and Beringia in Northwest Alaska. They colonized streams newly freed from the ice. However, ten thousand years ago the rivers and salmon habitat were unstable. Rivers recently released from ice lacked the stabilizing benefit of large trees. Salmon production must have been erratic. As the forests returned and stabilized the streams, salmon abundance increased. Five thousand years ago salmon numbers peaked. While there is evidence that Native Americans utilized salmon as early as nine thousand years ago, between four and five thousand years ago Native Americans developed salmon-based economies. Recent archeological studies at a south-central coastal area and at an inland area on the northern Columbia Plateau, showed remarkable stability in salmon use over a period of about 7,500 years.[4] That long period of stability changed with the arrival of Euro Americans in 1850. In the space of one hundred fifty years the abundance of salmon dropped to about 20 percent of historical levels (Figure1).[5] Shifting baselines, which we will discuss later, hid this perspective from the public. The only way to clearly see the failure of Euro American stewardship of the salmon is to place it visually in the context of the past 10,000 years.

The right side of Figure 1 puts the tragic failure of Euro American stewardship of Pacific salmon in perspective. The roots of the failure go back to 1875 and the advice given to the region by Spencer Baird, the first U.S. Fish Commissioner. He was responding to a resolution passed by the Oregon legislature asking how Oregon could maintain salmon abundance. At the time salmon were third in economic importance in Oregon behind wheat and wool. He recommended building hatcheries as the most economical way to maintain the salmon's abundance and surpass their natural productivity.[6] Based on Baird's unverified assumptions the region headed off on a course that has ended in disaster.



Deglaciation; low quality habitat, highly variable production	Stabilizing salmon habitat, expansion of old growth forests, increasing production.	Salmon abundance peaked – 5,000 years ago; Native Americans developed salmon-based economy	Euro Americans begin commercial harvest

Figure 1. Relative abundance of wild Pacific salmon in the Pacific Northwest states of Oregon, Washington, Idaho and Northern California for the past 10,000 years.[7]

Salmon management is one long unique event or experiment.[8] It is an experiment whose foundational hypothesis is that the abundance of salmon and the health of the salmon industry can be maintained through technology (hatcheries) that circumvents ecological processes and relationships. Eighty-five years after Baird's recommendation was adopted the Washington Department of Fisheries took this line of reasoning beyond circumventing ecological processes to the claim that salmon can be produced without rivers.[9] The idea of salmon without rivers was a part of the Oregon experiment in private salmon ranching in the 1970s and 80s. Juvenile salmon from private hatcheries were released directly to bays or to the ocean through artificial channels. It still continues in the salmon aquaculture operations in Washington State and British Columbia. We argue in this report that the failure of salmon management was due in large part to the conceptual foundation or assumptions about nature that managers adopted when they accepted Baird's recommendations. Another part of the reason for the failure was the significant cultural differences between the Native American and Euro American relationships with salmon.

Native Americans practiced a subsistence fishery for salmon for several thousand years. Subsistence fisheries are self-limiting. When enough salmon were harvested to feed the tribe, fishing stopped. The tribes enforced strict taboos on excessive harvest and waste.[10]

Shortly after the Euro Americans entered the Pacific Northwest the salmon fishery switched from subsistence to a capitalist, market-driven enterprise. The goal of a capitalist enterprise is to accumulate more and more capital.[11] There are no self-imposed limits, which may not be a problem for markets dealing with washing machines, automobiles or computers. For renewable resources like salmon, exploitation without an effective means of limiting harvest to sustainable levels leads to disaster (Figure 1). To compound the problem, early salmon managers were misinformed and misled by the assumption that hatcheries could maintain and even exceed the natural supply of salmon. This unverified assumption led to wholesale habitat degradation in exchange for hatcheries. The loss of habitat amounts to a significant ecological cost of the hatchery program. Even though hatcheries failed to stop the salmon's decline and contributed to the decline, salmon managers are still reluctant to acknowledge the failure of the original assumptions made in the nineteenth century.

Public Trust Doctrine

Salmon are a part of nature's trust, which creates a special obligation for the governmental agencies charged with their management. They must act as trustees of the wild salmon and protect them consistent with the long-standing public trust doctrine. Their obligation is to maintain the wild salmon legacy in good health for citizen beneficiaries of present and future generations. Salmon managers have abrogated that responsibility and have converted the prudent management of the wild salmon to the production of commodities for the benefit of sport and commercial fisheries. Making this the main focus of management amounts to the privatization of the trust. The salmon commodity is produced in a large industrial operation (hatcheries) for the benefit of a few. Reliance on this industrial production system has reduced or eliminated the salmon's ecological underpinnings and created the impoverishment of wild salmon that exists today.

Wild Pacific Salmon: A Threatened Legacy

Introduction

The extirpation of wild Pacific salmon in forty percent of their historical range in the Pacific Northwest[12] and the extensive listing of Pacific salmon stocks under the federal Endangered Species Act (ESA) are a strong signal that the current salmon management paradigm has failed.[13] Solutions to the problem of restoring impoverished wild salmon populations have proven elusive. A sense of frustration comes in part from the periodic reinvention of past solutions that have questionable performance records. For example, artificial propagation has a long history of being reinvented as the solution to salmon depletion.[14] Even after it became evident that hatcheries are part of the problem, they were rebranded as salmon conservation tools.

While this report is focused on the status of wild salmon in the Pacific Northwest, many of the salmon's problems are similar to those affecting other natural resources, including forests,[15] range lands,[16] water,[17] fisheries,[18] wildlife,[19] and agriculture.[20] The widespread failure of management across resource types and across different ecological systems suggests that the source of the failures is at a fundamental level common to all natural resource management, the level where basic assumptions about nature are made.[21] We will argue that resource management institutions themselves have contributed to the degradation of natural resources through the assumptions they make about how natural ecosystems function and how the species and services they support should be used. These assumptions are buried deep in the culture of management institutions, so deep that they are not recognized or evaluated, but they exert a powerful influence on an institution's decisions and policies and their outcomes.[22]

A Canadian biologist, John Livingston, has through the use of a powerful metaphor, given us a way to understand this dilemma. In his book, *Arctic Oil*, Livingston says environmental problems are like icebergs, because they can be divided into a small, visible part and a larger, hidden mass.[23] Livingston calls the small, exposed part of the environmental iceberg the issues; they are the highly visible effects of human activities. For salmon, the tip of the environmental iceberg includes dams, poor logging and grazing practices, excessive water withdrawals, industrial pollution, urban developments, poor hatchery and commercial aquaculture practices, and over harvest. Obviously, those issues are an important part of the salmon's problem. However, like the iceberg, there is also a large hidden component that is rarely the subject of scientific inquiry or media attention.[a] The submerged mass of the environmental iceberg hides from easy view the myths, assumptions and beliefs that legitimate the behaviors that create visible

[a] One recent exception is the Independent Science Advisory Board's examination of the conceptual foundation for the salmon recovery efforts in the Columbia River. See R. Williams, 2006 at Endnote 136. For a discussion of the conceptual foundation and its influence on salmon management see: D. Bottom, 1997 at Endnote 43; R. Williams, and 12 others, 1999 at Endnote 21; and C. Frissell and 4 others, 1997, A Resource in Crisis: Changing the Measure of Management, In *Pacific Salmon and Their Ecosystems: Status and Future Options*, Edited by D. Stouder, P. Bisson and R. Naiman, 411-44, Chapman and Hall, New York, NY.

issues and they ensure the persistence of ineffective solutions to the salmon's problem. In this report, we call the hidden mass of the environmental iceberg the conceptual foundation.

Fishery managers avoid responsibility for their failure in leadership and stewardship with the excuse that degradation and loss of productivity is the inevitable result of population growth and its attendant demands for development and economic growth. Their poor performance is excused with the claim that things would be a lot worse, but for their efforts. While there is some truth to that statement, it ignores a growing weight of evidence that the management institutions have contributed to the current state of natural resources.[24] In the following assessment of the causes of the wild salmon's decline in the Pacific Northwest, we will examine the hidden mass of John Livingston's environmental iceberg as it pertains to salmon management.

A segue into the examination of salmon management's conceptual foundation is the following statement from the book, *Harmony,* a new way of looking at our world by: Charles, Prince of Wales.

> *"I would suggest that one of the major problems that increasingly confronts us is that the predominant mode of thinking keeps us firmly on the wrong path. When people talk of things like an 'environmental crisis' or a 'financial crisis' what they are actually describing are the consequences of a much deeper problem which comes down to what I would call a 'crisis of perception'. It is the way we see the world that is ultimately at fault. If we simply concentrate on fixing the outward problems without paying attention to this central, inner problem, then the deeper problem remains, and we will carry on casting around in the wilderness for the right path without a proper sense of where we took the wrong turning."*[25]

In this quote, Prince Charles echoes John Livingston's description of a faulty conceptual foundation, but from a broader perspective.

3- Photo courtesy of Thomas Dunklin. Wild coho and steelhead, Mad River.

Salmon Management's Current Conceptual Foundation

A conceptual foundation is the set of principles, assumptions and possibly myths that gives direction to salmon management and restoration programs. It determines what problems (e.g., limitations on fish production) are identified, what information is collected, how it is interpreted, and as a result, establishes the range of possible solutions.[26] It can determine the success or failure of restoration and management plans because natural resource management carried out with the best intentions and methodological expertise can have disastrous consequences, if based on incorrect assumptions.[27]

To appreciate the importance of conceptual foundations, think of them as similar to the picture on a box containing a jigsaw puzzle. Each piece of the puzzle is a bit of information, but that information can only be interpreted by referring back to the picture on the box. Now imagine a puzzle that has the wrong picture on the box. For example, the picture on the box is a bouquet of flowers, but the pieces of the puzzle, when assembled, portray a sailboat on a stormy sea. The information on each piece of the puzzle, when compared to the picture, will either be misinterpreted, or it may be judged irrelevant and discarded. There is little chance the puzzle will be completed. Salmon management biologists must interpret a steady stream of information from research and monitoring programs and a host of journal articles and reports. Those bits of information are the pieces of the salmon management puzzle. If the myths and assumptions about nature that make up the conceptual foundation give a false picture of the salmon's ecosystem and its processes, a lot of relevant pieces to the salmon management and recovery puzzle, will be misinterpreted or ignored.[28]

The Columbia River is the place to start the examination of salmon management's conceptual foundation. It is currently the subject of the world's largest ecosystem restoration program.[29] The Columbia River's restoration program has the modest goal of an annual return to the river of 5 million adult salmon—historical salmon abundance was estimated at 10 to 16 million fish. In 1994, thirteen years after the Northwest Power Planning Council (Council)[b] initiated its restoration program, the abundance of salmon fell to a historical low of 749,000 fish. Faced with these discouraging results, the Council directed the Independent Science Group (ISG),[c] to undertake a review of the conceptual foundation of the salmon recovery 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 not reflect the latest scientific understanding of ecosystem science and salmonid restoration."*[30]

[b] Now the Northwest Power and Conservation Council.
[c] The Independent Science Group was a panel of eleven senior scientists and managers charged with reviewing the scientific quality of the Northwest Power Planning Council's Fish and Wildlife Program. The panel's name was subsequently changed to the Independent Scientific Advisory Board (ISAB).

The management institutions involved in salmon recovery in the Columbia River, were guiding the development and implementation of that program based on a set of assumptions that didn't reflect current scientific understanding of salmon ecology and their sustaining ecosystems.

The ISG identified three principles that characterized the flawed conceptual foundation. Since commodity production appears to be the primary purpose of the current conceptual foundation, we labeled the ISG's three principles as production principles. We also added an over-arching principle:

Overarching Principle

The salmon management agencies' highest priority is satisfying market demand for commoditized fish. To achieve this, it is acceptable to replace wild salmon with fish produced in an industrial process (hatcheries). Harvest and consumption of salmon are the primary goals and as such, are the drivers behind the flawed conceptual foundation.

Production Principle 1

"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."

Production Principle 2

"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."

Production Principle 3

"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."[31]

The first production principle implies that technology (hatcheries) is an acceptable substitute for healthy habitat and the ecological processes that wild salmon depend on. During construction of the hydroelectric system in the Columbia Basin (1933 to 1975), 211 dams were built.[32] This led to the massive loss of prime salmon habitat in exchange for a system of hatcheries that has been called "an often-overlooked industrial giant."[33] When the hatchery and commercial aquaculture operations across the Pacific Northwest are considered, it is indeed a "large industrial giant." The Bonneville Power Administration lists 208 salmon and steelhead hatchery programs spread across more than 130 anadromous fish hatcheries as part of the Columbia River Basin production system.[34]

In spite of the size of the hatchery program in the basin, it has failed to replace wild salmon production lost to habitat degradation.[35] The reliance on technology especially hatcheries is an example of halfway technology which focuses on symptoms instead of the underlying causes.[36] Pope Francis stated it this way: "Merely technical solutions run the risk of addressing symptoms and not the more serious underlying problems."[37] Salmon management's focus becomes the number of fish produced rather than the ecological processes that determine those numbers.[38] Within the management agencies, this approach seems normal because it is consistent with a conceptual foundation where the use of technology is intended to replace ecological processes.

The second statement assumes the ocean is simply a vessel that hatcheries can release juvenile salmon into without the possibility of over-filling it. It ignores the way the salmon's life history diversity buffers the effects of variable oceanic conditions.[39] The cause of fluctuations in the abundance of salmon may be changing ocean conditions over which we have little control, but those fluctuations are amplified by management practices such as poor hatchery operations and the failure to protect habitat. Those detrimental practices persist because they are consistent with the current conceptual foundation. They diminish life history diversity and its ability to buffer the impact of variability in the marine environment.

The final production principle encourages single species management. It ignores the numerous relationships among species of salmon and between the salmon and their ecosystem. Those ecological relationships are important to the survival of wild salmon; it is the unraveling of those relationships that leads to the extinction of a species or an individual population.[40]

The current conceptual foundation describes a salmon management paradigm that simplifies the production system by replacing ecological processes and relationships with industrial processes. The salmon production system is simplified to the point that salmon ecology, natural production and wild salmon fade from view and consideration. Fundamental to this approach is the overarching belief that technology can solve all production problems and successfully circumvent ecological processes. This belief is not limited to the Columbia River. The use of technology to compensate for human impacts on salmon-sustaining ecosystems is wide spread throughout the Pacific Northwest.[41]

The reliance on technology such as hatcheries is "culturally potent." It shapes attitudes and ways of thinking that reinforce the belief that technology can solve problems that have ecological origins. "Technologies shape feelings and fashion world views; the traces they leave on the mind are more difficult to erase than the traces they leave on the landscape."[42]

The current conceptual foundation lacks any concern or even acknowledgment of wild salmon as a legacy for future generations. The concept of legacy is not just a feel-good notion without any legal or political foundation. The public trust doctrine, a legal doctrine that goes back to early Roman Law, defines natural resources as the common property of all citizens that is held in trust for future generations.[43] Wild salmon and the rivers they inhabit are, we believe, an important part of that trust. That means management has a real responsibility for the legacy of wild salmon passed on to future generations. We also believe that salmon populations maintained by an "industrial giant" fails to meet the management agencies' trust responsibility.

The Council set a modest goal for salmon recovery of 5 million fish in the annual run returning to the Columbia River. It has failed to reach that goal after spending 17.9 billion dollars over 34 years.[44] We believe this result is due, in large part, to the faulty conceptual foundation that guides the development and implementation of the recovery program. That conceptual foundation is also a major contributor to the extirpation and impoverishment of wild salmon throughout the Northwest.

The current conceptual foundation, as portrayed above does not by itself adequately explain the loss of wild salmon in the Pacific Northwest. However, it sets behavioral norms and practices in agencies that have direct consequences for salmon and their sustaining ecosystems. Those practices, even though detrimental to wild salmon, persist because they are consistent with and justified by the conceptual foundation. We will examine four of those practices here:

1. The focus on production of commodities;
2. The shifting baseline syndrome;
3. The failure to recognize the importance of the salmon's strong connection to place; and
4. The fragmented management of wild salmon-sustaining ecosystems.

Salmon Management Focuses on the Production of Commodities

> *"And most important, only when governments that typically ensure economic interests and values over all others decide that they are willing to re-construct the human-salmon relationship as an ecological one rather than an economic one will the true salmon wars, the wars between society and the salmon, ever be over."*[45]

Are wild Pacific salmon commodities embedded in a market economy or are they sentient animals embedded in a web of ecological relationships?

The simple answer is yes to both. Wild Pacific salmon are a commodity in a capitalist, market-based economy[46] and wild salmon are sentient animals embedded in and sustained by a web of ecological relationships. This creates a problem for salmon managers because economic priorities and ecological reality often conflict. We need to dig deeper for a better answer than simply yes to both questions.

Salmon management agencies are charged with a dual mission. They must ensure a steady supply of commoditized salmon to the sport, commercial, and subsistence fisheries and the market economies they support. They are also charged with maintaining the ecological health of wild salmon and their sustaining ecosystems. The two missions can and often do conflict.[47] The conflict is between economic principles and priorities and ecological principles and priorities. Balancing the two missions should be a straightforward task because the human economy is a subset of and dependent on the larger biophysical environment.[48] The supply of commoditized salmon ultimately depends on the health of the ecosystems. However, fisheries management throughout its history has focused on one half of its mission: expanding the fisheries and providing commoditized fish to the detriment and endangerment of wild salmon and their ecosystems.[49]

To understand how salmon management took the wrong turn and focused on commodities, we need to go back to its beginnings in the late nineteenth century. In 1875, people concerned about the supply of salmon, had a very rudimentary understanding of salmon ecology. For example, some biologists did not believe that salmon returned to their home stream to spawn. This piece of salmon biology did not get resolved until early in the twentieth century.[50] In 1875, the U.S. Fish Commissioner, Spencer Baird, said that habitat degradation, over harvest and dams would diminish the abundance of Pacific salmon. He believed it would be too difficult and expensive to prevent the impact of these activities through regulation. He offered a solution. Baird said hatcheries would make salmon so abundant it would eliminate the need to protect habitat, regulate harvest and prevent the construction of dams.[51] Technology in the form of hatcheries gave humans control over salmon production. Because Baird and his colleagues believed that human control over reproduction was more efficient than natural production, the use of hatcheries would break the natural limitations on salmon abundance.[52] This was reflected in the policy of the U.S. Fish Commission which believed it was "…better to expend a small amount of public money in making fish so abundant [using hatcheries] that they can be caught without restriction. …rather than to expend a larger amount in preventing people from catching the few that still remain after generations of impoverishment."[53]

However, because Baird had little knowledge of the salmon's ecology, his recommendation was based on unproven assumptions like the one quoted above. Over time, the assumptions became beliefs and later hardened into dogma. The latter made hatcheries exempt from any meaningful evaluation. For many years after 1875, hatcheries were the only tool in the managers tool box. The Oregon Game Commission hired its first biologist in 1917, 42 years after Baird set salmon management on its current course. The biologist, William Finley, did not blindly accept the use of hatcheries and believed fish and wildlife management should adopt an ecosystem perspective. These were not welcome ideas in an agency dominated by fish culturists; he was fired two years later in 1919. As late as 1936, out of 271 positions in the Oregon Fish Commission, only one was a biologist.[54]

One might argue that those events are what happened in the past and they are not representative of salmon management today. However, the following took place just a few months ago. During the last session of the Oregon Legislature, there was an attempt to strengthen the State's Wildlife Policy and make it more responsive to the conservation needs of fish and wildlife. A staff person at the Oregon Department of Fish and Wildlife commented that the changes would somehow elevate conservation of wildlife resources over utilization, and a lot of people would not like that.[d] This clearly indicates to us that the Oregon Department of Fish and Wildlife still gives commodity production a higher priority than conservation. It also expresses the fallacy that utilization is not, in the end, tied to and dependent on conservation.

Baird's recommendation to emphasize hatcheries provided little room for science. This left the U.S. unprepared, in the 1920s, for scientific discussions with Canadians on transboundary fisheries for Pacific salmon and halibut.[55] Given Baird's naïve assump-

[d] Personal communication, Jim Myron, Portland, OR 2017.

tions about hatcheries, the human economy over harvested salmon, built dams to power economic growth, withdrew water from rivers to increase farm contributions to the economy, and undertook many other activities that harm wild salmon populations and degraded their habitat. The abundance of commoditized salmon available to the sport and commercial fisheries declined (see Figure 1). We now know that hatcheries failed to maintain the supply of salmon and contributed to their current impoverishment.

For more than a century, salmon management has focused on maintaining the supply of commoditized salmon and maximizing their economic returns.[56] This led to management performance measured by an economic rather than an ecological yardstick.[57]

Measuring Management Performance

The Economic Yardstick

Natural resource managers who have as part of their mission the production of a commodity often create a simplified model of the production systems they manage.[58] The simplified model focuses on the commodity: the number of fish harvested, number of logs harvested, the number of irrigated acres, and so on. When the focus is on the commodity, ecological relationships that sustain the production of the commodity fade into the background and disappear from the manager's view. The commodity's abundance is the primary measure of management performance. This reduces the amount and complexity of information used to "manage" and at the same time gives the illusion of control and predictability.[59] The simplification is facilitated in salmon management by the ease with which salmon can be artificially propagated. The hatchery is the ultimate tool for commodity production in salmon management.

When the focus is on commodity production, managers measure success by an economic yardstick, rather than an ecological yardstick.[60] This is evident today in the statistics the management agencies use to measure and report their performance to the public such as:

- Sport and commercial catch
- Angler days
- Economic value of the catch
- Licenses sold
- Numbers of fish released from hatcheries
- Escapement (to determine if all the available fish were harvested)
- Benefit-cost analysis of hatchery programs that ignore ecological costs of hatcheries.

The Ecological Yardstick

The metrics noted above describe the performance of the agency's commodity production but, say little or nothing of the ecological state of the salmon-sustaining ecosystems.[61] To achieve a real balance between commodity production and the ecological health of the wild salmon-sustaining ecosystems, we recommend that management agencies adopt ecosystem vital signs as measures of ecological performance such as:

- Sustained return (and size at maturity) of spawners to all spawning habitat in numbers that provide conservative accounting for environmental variation.
- Sustained habitat-specific density and growth of juveniles.
- High habitat connectivity and productivity in freshwater, estuary and ocean.

- Natural, seasonal flow patterns.
- Natural, seasonal temperature patterns.
- Productive biodiverse food webs with strong riparian linkages and sustained inputs of marine derived nutrients, i.e., salmon carcasses, naturally deposited after spawning.
- High salmonid biodiversity (diverse life histories).
- Natural or normative water chemistry (minimal pollution).
- No cultured stock introductions or supplementation.

The simplification of the salmon's production system into an industrial process seemingly under human control while ignoring the ecological processes that support natural production is consistent with the current conceptual foundation. Even a cursory look at the two sets of performance measures shows the current set focuses on commodity production and the ecosystem performance measures focus on ecological processes that sustain wild salmon.

Using an economic yardstick is useful to salmon management agencies for some purposes such as building budget requests for the governor and legislature. However, if the use of economic metrics strays too far from ecological reality, the result will be misinformed and mislead political leaders and fish and wildlife commissioners. An example of a fisheries administrator trying to justify letting ecological concerns fade into the background and disappear occurred recently. The following was taken from a personal communication (e-mail) from Jim Myron. [62]

> *"Included in the documents posted on ODFW's web site the other day relative to the draft Coastal Management Plan [CMP] was the following response from the agency to a statement from the IMST [Independent Multidisciplinary Science Team] regarding the costs of the coastal hatchery program:*
>
> *<u>IMST Statement</u>*
>
> *Hatcheries – Given the mission dilemma but the documented risk to wild populations, the CMP needs stronger arguments regarding the ecological and fiscal costs of hatchery production. IMST supports a rigorous economic analysis of long-term ecological/fiscal costs.*
>
> *<u>ODFW Response</u>*
>
> *ODFW has identified as a baseline plan assumption that the release of hatchery fish incurs some level of risk to wild populations, but the level of risk imparted from any individual hatchery program is difficult to quantify. For this reason alone an analysis of the long-term ecological/fiscal costs would be problematic. In addition, trying to quantify the fiscal costs of the hatchery impact, and the costs associated with that impact being removed would require a broad range of assumptions to be made. It would also be appropriate to balance that analysis with the fiscal benefits of the hatchery programs – again requiring many assumptions. In addition, there are severe difficulties when trying to monetize services or attributes that are not traditionally assessed an economic value but is nonetheless relevant to a C/B analysis. ...Therefore, ODFW believes undertaking such an analysis would likely have no benefit to guiding management direction in the CMP."*

This convoluted explanation can be summarized by one word – externality. ODFW treats the negative effects of its hatchery program on wild salmon as an externality. In economics, an externality is an unintended negative or positive consequence of an activity, which is ignored when computing costs or benefits. For example, pollution from a factory that reduces the number of fish and the fishermen's catch in a river is a negative externality if the factory owners fail to account for that cost when computing the factory's profits. In the statement above, ODFW recognizes that their hatcheries impose an ecological cost on wild salmon and steelhead, but those costs are ignored when defending the hatchery program. There is no justification for ignoring the ecological cost of hatcheries. Over the past 30 years or more, the negative effects of hatcheries on wild salmon have been extensively documented in the scientific literature. Many of those studies have determined the survival differential between wild salmon and hatchery origin salmon. There is enough documentation to develop an estimate of the range of possible survival costs that a hatchery could impose on wild salmon. The cost-benefit analysis would then be bounded by a range of impacts on salmon from a smaller survival cost to the highest survival cost. It should be considered dishonest to know there are ecological costs imposed by hatcheries on wild salmon yet ignore those costs in a deceptive cost-benefit analysis.

The current impoverished state of wild salmon has many causes, but most of them are connected to the time a century and a half ago when wild salmon became a commodity. The commodification of salmon and all it entails is the underlying cause of the wild salmon's decline.[63] The salmon commodity retains only one value – the exchange value in the market economy. The value of commoditized salmon leaves no room for wonder at the diversity of life in nature, no concern for other sentient beings, no recognition of the ecological attributes that sustain wild salmon across generations, and therefore, no concern for the legacy future generations will inherit. It's just dollars and cents and wild salmon and steelhead be damned. When management agencies put their focus on the production of commodities they must practice a sort of linguistic gymnastics to make failure into success, and in the words of George Orwell, "give an appearance of solidity to pure wind."[64] It's time to rethink the dogma that led wild salmon to this point.

Hatcheries, aquaculture and commoditized salmon: time to rethink the dogma.

> *"Neither hatcheries nor aquaculture systems restore salmon runs or mend ecological rifts. They serve as a means to further the production of commodities."*[65]

What happens when a government agency follows inherited dogma and invests a large amount of public funds in infrastructure only to find that implementing the dogma will not produce the expected results? The use of hatcheries has expanded for a century without changing the fundamental story. Government staff accepted the dogma, and they invested significant resources into programs supporting it. They deal with the dogma's failure by simply reinventing expectations and using terminology that sounds up-to-date. Belief in the efficacy of hatcheries is potent and bolstered by exaggerated claims of success. When hatchery programs underperformed, and recognition of failure was unavoidable, managers simply changed the hatchery goal and reduced their expectations. Here is a brief history of the expectations and terminology used to periodically reinvent hatcheries.

In the late nineteenth century, salmon managers believed hatcheries would enhance the supply of salmon beyond natural limits. Hatcheries would replace inefficient ecological processes that the managers did not understand with technology they could control. Hatcheries failed to achieve that goal and salmon began to decline. By the 1920s, the goal of hatcheries shifted. Now they were going to stop the decline and maintain the supply of salmon. Salmon continued to decline. In the 1940s, mainstem dams and river development emerged as a new threat to the salmon. Without clear evidence that hatcheries had achieved their previous goals, managers once again stuck with the dogma. Now the goal changed to mitigate the negative effects of dams and development. Through the 1940s, 50s and 60s, mitigation was synonymous with hatcheries. Salmon continued to decline.

The depleted state of the salmon reached critical levels in the late 1970s and led a decade later to petitions to list wild salmon under the federal ESA. Salmon managers now faced a new problem: How to prevent extinction and increase salmon abundance to levels that would remove them from threatened or endangered status. Once again fish managers tacked a new name and a new mission on the same old dogma and presented it as the solution to the new problem. The new names for hatcheries – supplementation, conservation, or captive brood hatcheries – reflect twenty-first century problems chained to a nineteenth century tool that has a record of failure. Doesn't this sound like the old saying: if the only tool you have is a hammer, then every problem looks like a nail. The stubborn adherence to an industrial production system that is destroying wild salmon-sustaining ecosystems strongly suggests that salmon management institutions and their leaders have lost sight of their mission. [66]

The persistent adherence to outdated assumptions and the dogma derived from them has had a devastating effect on wild salmon and steelhead. The willingness to overlook the failure of fish culture and accept hatcheries as mitigation for habitat destruction has been a major and as yet, undocumented direct cost of hatchery programs. Hatchery fish reduce viability of wild salmon when they interbred. Wild salmon are overharvested in fisheries on mixed hatchery and wild stocks. Predator attraction and competition for food occur with a massive release of hatchery fish in rivers. Hatcheries reduce the genetic and life history diversity of propagated salmon.[67]

Salmon aquaculture: making the world outside the net pens increasing unfit for fish and fishermen[68]

> *"We will domesticate the fish over time. … knock them down to a more passive fish. … And we will have fish that will just swim around and graze like a cow. …That's what we are all shooting for."*[69]

Conventional hatcheries release juvenile salmon into rivers where they migrate to sea and complete the rest of their life cycle in a somewhat natural way. But, conventional hatcheries do not provide the efficiency, control and wealth generation desired by those who treat salmon only as a commodity. To remedy this, entrepreneurs created a feed lot system to produce salmon commodities. It is based on the same principles that led to conventional hatcheries: control over production and bypass the natural limits on abundance. The feed lot system or salmon farms consist of large pens enclosed by netting where the salmon remain under control of their human caretakers. The salmon never have the freedom to roam the sea. In the salmon farm, the natural life cycle is modified to provide a stream of commodities on a schedule dictated by market demands. But these changes in the commoditized salmon were not enough. Farmed Atlantic salmon were genetically modified to make them grow faster and be a more profitable commodity. The U. S. Food and Drug Administration approved these modified fish for human consumption on November 19, 2015. Aqua Beauty Technologies, the creator of the genetically modified salmon, said that they are exactly like wild salmon. No, they are human constructs dressed in the skin of a salmon.

Washington State has eight salmon farms operating in Puget Sound. They raise the nonnative Atlantic salmon. All the other west coast states have excluded Atlantic salmon farming. It is estimated that British Columbia has 138 salmon farms.[70] Like hatcheries, salmon farms are touted as a means to protect wild salmon, but also like hatcheries the salmon farms have a large number of negative impacts on wild salmon. They are different in many respects from the negative impacts of hatcheries, but they are devastating just the same. Here are some of the problems salmon farms create for wild salmon:

- "Polluting local waters with millions of pounds of untreated waste;
- The spread of lethal sea lice to wild salmon;
- Disease outbreaks that spread to wild fish;
- Pesticide induced die offs of shrimp and crabs;
- Whale, otter, and seal deaths cause by entanglement in net pens;
- Nonnative Atlantic salmon escape the farms; and
- Lax government oversight characterized by:
    1. Washington State relies on unen-forceable recommendations for this industry, instead of enforceable regu-lations.
    2. Washington State allows the industry to self-monitor.
    3. The net pen industry lacks transpar-ency and has the ability to hide behind the veil of "proprietary information."[71]

The problem of escaped nonnative salmon received a lot of attention recently when 263,000 nonnative Atlantic salmon escaped from one of the salmon farms in Puget Sound. Releasing that many nonnative salmon into Puget Sound is an ecological disaster of monumental proportions. The Washington legislature recognized the seriousness of the problem. On February 2, 2018, the Washington State Legislature passed and the governor signed a bill to phase out Atlantic salmon farms in Puget Sound.[72] This is a significant positive event in the long trail of impoverishment of wild Pacific salmon. It's too soon to see, if it represents the first steps in the rollback of the focus on commodities in salmon management.

Can the Tide be Turned?

Salmon management in the Pacific Northwest is in a crisis that requires a shift toward a new conceptual foundation. Looking beyond the Pacific Northwest, recent advances in salmon management in Norway and Scotland provide examples of regional and local management for Atlantic salmon populations that are based on scientific evidence and measured using ecological parameters. The actions are consistent with the alternative conceptual foundation for salmon management we present in this document. The discussion of Norway's innovative salmon management appears on page 30.

Scotland. The River Dee is one of Scotland's primary Atlantic salmon producing rivers as well as a famed salmon fishery. Numbers of rod caught Atlantic salmon have undergone a long-term decline sufficient to indicate a downward population trend. The watershed managers, the Dee Board and Dee Trust, commissioned an independent study to determine whether the decline could be reversed by stocking hatchery origin Atlantic salmon to boost rod catches.[73]

The independent commission reviewed the literature on stocking, hatchery fish performance, and ecological impacts. It conducted an economic analysis of the costs of building and operating a hatchery to produce smolts to support increased rod catches. The independent commission concluded that it was not appropriate to stock the Dee with Atlantic salmon of any life history stage. The commission went on to explicitly note:

"The literature review also conclusively demonstrated that stocking of Atlantic salmon on the Dee will risk the future of the wild population. The published scientific literature shows that stocking negatively impacts every life stage of naturally produced salmon stocks. Survival rates of stocked fish are held to be very low. This view is now widely accepted by the academic, regulatory and management fields and has led to the banning of stocking in Wales." [74]

The commission concluded that stocking would risk the biological integrity of the wild Atlantic salmon population in the Dee and would be enormously expensive. The commission recommended improving the quality and quantity of habitats in the river rather than stocking. The conclusions of the report were accepted by the Dee Trust and Dee Board, and actions are presently underway to implement the recommendations.[75]

We devoted extra space to the focus on commodity production in salmon management because it is a pervasive problem that underlies much of current salmon management in the Pacific Northwest. The focus on commodity production with its simplified production system, is easier to implement than managing for healthy wild salmon populations. It can conveniently state benefits in monetary terms—the preferred language of legislatures and fish and wildlife commissions. However, Richard Leaky and Roger Lewin warn us that, "Ecologists have largely allowed economists to set the terms of the debate over the value of biodiversity. The danger is, that having accepted the invitation to enter the lion's den, they are likely to end up as the lion's dinner."[76]

Shifting Baselines – The Problem of Declining Expectations

Fisheries biologist, Daniel Pauly, introduced the concept of a "shifting baseline syndrome" in 1995. It describes the lack of awareness of fisheries professionals and the general public of the magnitude of the decline in fish harvest and abundance that took place by the late twentieth century.[77] 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."*

This results in a gradual downward shift of the baseline, an unconscious acceptance of the disappearing resource, and the use of false reference points for setting recovery targets and evaluating species responses to management actions.

Unfortunately, reliable historical datasets that might serve as baselines are often not available. 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. Roberts 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."*[78]

Shifting baselines persist because salmon managers generally have shown little interest in the history of their profession and its record.[79] Callum Roberts may have succinctly given us the reason for the lack of historical perspective when he said, "Experience has a bitter taste in fisheries management."[80]

When the baseline is lowered over several generations, it 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. Here 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."[81] 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.[82] 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.

Shifting baselines are an impediment to institutional learning and they help administrators of fish and wildlife agencies evade accountability. Because a shifting baseline conceals the real magnitude of loss and even creates "record" runs out of impoverished levels of abundance, there is really no need to search for an alternative approach to management or to learn from mistakes. We should always be aware of the real loss of wild salmon and where our recovery efforts lie relative to the historical condition. For obvious reasons managers and administrators prefer shifted baselines.

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 reproduction 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."*[83]

Today's administrators of fish and wildlife agencies should not be blamed for the massive impoverishment of salmon that occurred before their time, but they should not be allowed to conceal the magnitude of the problem by shifting the baselines forward. A shifted baseline that creates periodic "record" runs of salmon encourages managers to continue the current program even if it has contributed to the decline of wild salmon. The hatchery programs are an example of that problem.

A shifting baseline also reinforces the faulty conceptual foundation. Managers that are not aware of the wild salmon's historical productivity will falsely believe that the impoverished state of the salmon is the real baseline. They will believe it is what natural production can be expected to achieve and cause them to conclude that wild salmon cannot be expected to make a significant contribution to the existing fisheries. We have frequently heard managers claim that natural production cannot sustain a fishery. This belief persists even though historically, natural production sustained harvest levels that have never been equaled by artificial propagation. We characterize this attitude on the part of salmon managers as a loss of "faith in nature."[84] The loss of faith in nature justifies the reliance on hatcheries and reinforces the flawed conceptual foundation.

A recent study showing the recovery of a wild coho salmon population in the Salmon River, a coastal river in Oregon, 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: adult wild coho salmon abundance increased and spawning timing moved from the artificial hatchery timing to more natural timing for the Oregon coast.[85]

Failure to Recognize the Importance of the Salmon's Strong Attachment to Place

Wild salmon have a strong attachment to the stream and even a specific stream reach where they began life. They return to those places to spawn generation after generation following their long oceanic migrations. This attachment to the place of their birth is the wellspring for the important attributes of local adaptation, biodiversity and resilience.[86] Those attributes were partly responsible for the rich, historical abundance of salmon. To be successful, management must recognize and nurture the wild salmon's attachment to place.

How have management agencies treated the salmon's attachment to place? To answer that question, we will examine two key activities: hatcheries and harvest. Hatcheries are a technological substitute for place. Hatchery incubation trays and raceways replaced streams and natural habitat. The environmental conditions in the wild salmon's home stream, the conditions they are adapted to, do not enter into the factory-like operation of the hatchery. In this regard, hatcheries are more closely related to cattle feedlots than to healthy rivers. When domesticated, hatchery salmon stray into the natural spawning grounds and spawn, their offspring find it difficult to survive. This makes salmon of hatchery origin ecologically placeless[e] and science tells us that domestication, which is demonstrated by lower survival after release from the hatchery, begins immediately after wild salmon are taken into a hatchery.[87] In addition, when it is acceptable practice to supplement natural production with hatchery fish, it weakens the incentive to vigorously protect habitat.

Aquaculture or salmon farms intensify the problems of conventional hatcheries. The salmon are genetically modified, their life histories modified to meet market demands and the feed lot way of raising these pseudo-salmon makes them a threat to wild fish when they escape captivity.

Two events in the closing decades of the nineteenth century and opening decades of the twentieth century contributed to a placeless approach to harvest management. First, switching from sail to gasoline engines to power their vessels gave fishermen the ability to move from the river to the ocean where they intercepted salmon before they entered their home river.[88] Fishermen no longer harvested only local stocks after they entered their home streams, but mixed aggregates of stocks from several rivers while they were still in the ocean. Salmon targeted in the ocean fisheries might be caught several hundred miles from their home river.

The rapid growth in ocean salmon fisheries coincided with the creation of resource management agencies staffed with technical experts.[89] Centralized decision making led to uniform harvest regulations over large oceanic areas. Uniform regulations were applied to aggregates of several different stocks regardless of the productivity and status of the individual populations.[90] After describing the importance of understanding how salmon populations are adapted to their local habitats, W. F. Thompson described the

[e] The idea of ecological placelessness comes from John Livingston's book, Rogue Primate: An Exploration of Human Domestication.

consequences of the mixed-stock ocean fisheries.

> *"But we do not know much about these independent, subspecific 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 effects completely. … knowing only that our total catches diminish, as one by one small populations disappear unnoticed from the greater mixtures which we fish."*[91]

Harvesting mixed stocks of salmon in the ocean and trying to compensate for resulting diminished supply of fish by making ecologically placeless animals in hatcheries is placeless management. What did placeless management accomplish? In the Pacific Northwest, salmon are now extinct in at least 40 percent of their historic range and the salmon in most of the remaining range are under the protection of the federal ESA. Management that ignores one of the wild salmon's important biological attributes – a strong attachment to place – is bound to fail, and it has failed.

Fragmented Management of Salmon-Sustaining Ecosystems

During their long migrations, the salmon cross the jurisdictions of federal, Tribal, state, city, county and private institutions. All of these organizations can make decisions that affect the salmon. For example, a juvenile salmon leaving the Lochsa River in Idaho will pass through the boundaries of 17 different salmon management agencies[92] and the boundaries of several other public and private institutions whose activities can affect salmon and their habitat. Some of those institutions have primary missions that conflict with wild salmon conservation. The management of ecosystems in the Pacific Northwest is fragmented among these public and private institutions and this has contributed to the lack of an ecologically coherent stewardship program for wild salmon. What we see when we examine this management structure are ecosystems fractured into pieces that look more like what one sees when looking into a kaleidoscope.[93]

An ecosystem fragmented among several institutions is a maze of bureaucratic boundaries that are vigorously defended. Salmon managers find it hard to protect habitat that falls in the domain of other state or federal agencies such as, the Department of Environmental Quality, the Environmental Protection Agency, state and federal forest management agencies, the Department of Water Resources, the Corps of Engineers, Bonneville Power Administration, and many others. Crossing a bureaucratic boundary to protect habitat can get a fishery biologist into conflict with another state or federal agency and the individual may be labeled a troublemaker by his or her own agency. Fragmented management of ecosystems and the bureaucratic boundaries it creates encourages salmon managers to avoid conflicts with other agencies. This leads to a lack of effective habitat protection.

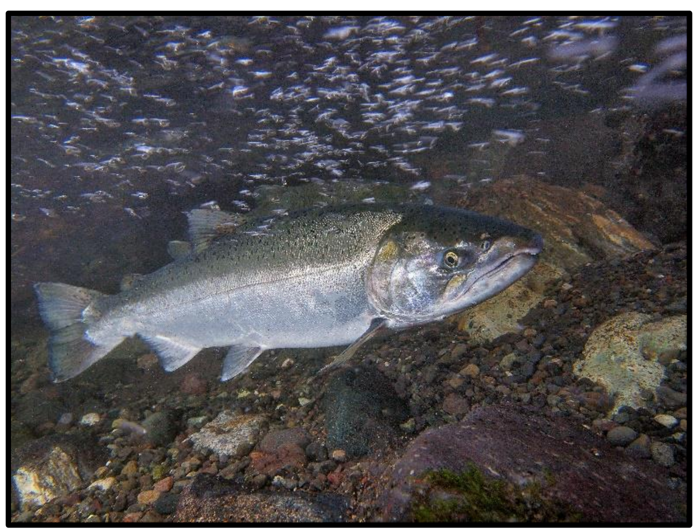
Salmon management's reliance on hatcheries and the fragmented management of ecosystems have been coevolving for more than a century. As they coevolved, each adapted to and reinforced the other. The result is a management paradigm that gives primary importance to hatcheries and harvest regulation because those two activities fall wholly within the boundaries of the ecosystem fragment allotted to fisheries. It also reinforces the focus on commodity production. Management agencies can operate hatcheries and regulate harvest without crossing the bureaucratic boundary of another agency. Those two activities define the agency's comfort zone, which is why, despite repeated warnings of its damaging effect on wild salmon, there has been no serious attempt to change the fragmented management of ecosystems.[94]

Science tells us that we should be taking an ecosystem approach to the management and recovery of Pacific salmon,[95] but such an approach is not compatible with the current fragmented management of ecosystems. Attempts to overcome the bureaucratic boundaries fail because the special interests those boundaries protect are a formidable obstacle. So, the coevolved institutional structure and the industrial production system remain, even though they clash with the wild salmon's unique life history and their extended ecosystem.

Summary

This discussion deviated somewhat from the conventional explanation for the wild salmon's impoverishment. Most accounts of the wild salmon's decline focus on the visible tip of John Livingston's environmental iceberg. Those problems such as dams, poor logging practices, excessive water withdrawals, over-grazed riparian zones, over harvest of wild salmon and poor hatchery practices are real and have serious effects on wild salmon. They need to be confronted and corrected. It is also important to recognize that the actions in the visible tip of the environmental iceberg are not independent of the large hidden mass. The assumptions about nature embedded in the hidden mass legitimate behaviors that create the visible issues.[96] We cannot hope to change the visible issues until we change their underlying causes.

The current conceptual foundation simplifies the salmon production system to an industrial process that focuses on the number of salmon. As a result, this has reduced the salmon's problem to simply not enough fish. The conventional solution to this problem is more hatcheries. However, the lack of fish is not the problem. It is a symptom of the real problem, which is the degraded state of the salmon's sustaining ecosystems. A conceptual foundation that defines the problem in terms of symptoms will have difficulty identifying an appropriate solution.



4-Photo by John R. McMillian. Wild adult coho salmon.

The Solution: An Alternative Conceptual Foundation

The current conceptual foundation simplified the wild salmon's natural production system to an industrial process (hatcheries) and a command and control management paradigm that assumes problems are "…well-bounded, clearly defined, relatively simple and linear with respect to cause and effect."[97] However, problems encountered in natural resource management, often have complex and nonlinear causes that arise from the same ecological processes that were ignored when the natural production system was simplified. The failure to recognize the real ecological source of the salmon's problem leads to a pathology manifested in less resilient wild salmon-sustaining ecosystems, agency staff increasingly isolated from those ecosystems, and an institutional myopia and rigidity that ignores concerns expressed by the public.[98] In our careers, we have seen the symptoms of this pathology many times. Any attempt to remedy the pathology afflicting wild salmon management must begin with a new conceptual foundation that links the salmon to their habitat and key ecological processes and includes recognition of the value of wild salmon as a public trust and a legacy for future generations.

Since 1939, salmon managers have been encouraged to treat the population as the basic management unit. Here is how salmon biologist, Willis Rich, described it:

> *"In the conservation of any natural biological resource 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. 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…."*[99]

Maintaining the health of salmon-sustaining ecosystems and ultimately the production of wild salmon starts with a focus on the individual populations, their biological attributes, and ecological relationships. Salmon management institutions must recognize that a focus on commodity production using a set of assumptions that simplify the wild salmon's sustaining ecosystems have dominated management for over a century. The irony of that approach is that the intended beneficiaries of a focus on commodities, the sport and commercial fishermen, paid a high price as salmon abundance declined.

Modifying the current conceptual foundation and correcting its negative consequences requires a different set of assumptions about how nature works – a different way of thinking about nature. It requires a conceptual foundation that highlights ecological relationships relevant to local populations. Bill Liss and his colleagues developed an alternative conceptual foundation that addresses those ecological concerns.[100] It consists of three conservation principles. It was originally developed during an analysis of the salmon restoration program for the Columbia River, but is, we believe, broadly applicable in the Pacific Northwest. For this report, we added an overarching principle that recognizes the importance and value of wild salmon as a public trust and our obligation to pass on a meaningful legacy to future generations.

Overarching Conservation Principle: Salmon as a Legacy

Wild salmon and the rivers they inhabit are a public trust. They cannot be transferred to private ownership or intentionally diminished. We have the collective obligation to hold this trust for the use and enjoyment today and as a legacy for future generations. Government agencies acting as trustee of wild salmon and their sustaining ecosystems must, "show absolute loyalty to the citizen beneficiaries."[101] In discharging the trust responsibility, the public and government trustees must let future generations see the natural world as it was and not as the remains of market driven consumption and technological substitutions.

Conservation Principle 1: The Scope of Salmon-sustaining Ecosystems

> *"Restoration of Columbia River salmonids must address the entire ecosystem, which encompasses the continuum of freshwater, estuarine, and ocean habitats where salmonid fishes complete their life histories. This consideration includes human developments, as well as natural habitats."*

Conservation Principle 2: Linkage between Connectivity and Productivity

> *"Sustained productivity requires a network of complex interconnected habitats, which are created, altered, and maintained by natural physical processes in freshwater, the estuary, and the ocean. These diverse and high-quality habitats, which have been extensively degraded by human activities, are crucial for salmonid spawning, rearing, migration, maintenance of food webs, and predator avoidance, and for maintenance of biodiversity. Ocean conditions, which are variable, are important in determining the overall patterns of productivity of salmon populations."*

Conservation Principle 3: The Importance of Diversity

> *"Genetic diversity, life history diversity, and population diversity are ways salmonids respond to their complex and connected habitats. Those factors are the basis of salmonid productivity and contribute to the ability of salmonids to cope with environmental variation that is typical of freshwater and marine environments."*[102]

The conservation principles are hierarchical. The overarching conservation principle recognizes the broad responsibility to maintain and restore wild salmon as part of our obligation toward future generations and toward salmon as a public trust. Those obligations have priority over the consumptive uses of wild salmon.

The first conservation principle addresses the salmon's extended ecosystem and the chain of habitats where they complete their life histories. Wild salmon restoration and management must take a whole ecosystem and whole life history approach and not focus on a few individual links in the life history-habitat chain while ignoring others. The second conservation principle focuses on the quality of the interconnected habitats, the natural processes that create and maintain them, and the link between interconnected habitats and long-term natural production. The individual populations, their genetic and life history diversity and their inter-population diversity are considered in the third conservation principle.

To facilitate comparison between the current and alternative conceptual foundations, we placed them in Table 1. We rearranged the original order of the principles to make comparison easier. We identified management practices derived from the current conceptual foundations as coarse grained and practices derived from the proposed alternative conceptual foundation as fine grained.[103] The current conceptual foundation is markedly simple and lacking in ecological considerations or an ecosystem perspective, which naturally leads to a reliance on technology such as hatcheries. It is a coarse-grained management paradigm.

Hatcheries are a major component of the current conceptual foundation; however, they are not compatible, or of very limited use in the alternative, ecological conceptual foundation. This paradox demonstrates the critical importance of conceptual foundations. We have shown two conceptual foundations: The current one based on a simplified, technology dominated production system focused on commodity production; and an alternative, ecological conceptual foundation focused on salmon-sustaining ecosystems, natural production and compatible harvest regimes. Both can be used to identify problems and their solutions. But those problems and solutions will be very different for the two conceptual foundations. For over a century the current conceptual foundation has been guiding salmon management and recovery programs with a poor record of results. We are rapidly approaching a crossroads where the impoverished state of wild salmon will become irreversible. It's time to take a different path.

The difference between the two conceptual foundations reflects the failure to incorporate the latest science into salmon management programs and their underlying conceptual foundation,[104] while at the same time clinging to outdated assumptions about nature and the role of humans as stewards of natural resources. That this approach has a record of failure is obvious, but the status quo is just too comfortable to risk a change.

The disparity between the current conceptual foundation's production system (and the institutional structure that supports it) and an alternative, ecological conceptual foundation explains the federal court's consistent rejection of a series of biological opinions (BiOp) over the past 25 years. During this time period, NOAA Fisheries released a series of eight separate BiOps to identify the impacts of the Federal Columbia River Power System (FCRPS) on ESA listed salmon and steelhead stocks and develop management actions to offset the jeopardy caused by those hydro-system impacts. Each of the BiOps has been challenged and all but two have been overturned in federal court for failure to take salmon recovery seriously, including the possible removal of lower Snake River dams. Judge Michael Simon of the United States District Court, District of Oregon invalidated the most recent BiOp on May 16, 2016.[105]

Table 1. The current and proposed conceptual foundations characterized as coarse grained and fine grained for the salmon mitigation program underway in the Columbia River.

Guiding Principles -------------- Summary Comparison	Comparison of Conceptual Foundations (CF): Type / Focus Current CF Coarse Grained / Commodity (salmon) Production	 Alternative CF Fine Grained / Salmon-sustaining Ecosystem
Overarching Management Principle The concepts and assumptions that encompass and guide all activities in a management agency.	Satisfying market demands for commoditized salmon is the highest priority.	Salmon are a public trust and a legacy for future generations. The primary obligation of salmon management agencies is to act as trustees of wild salmon.
<u>Principle 1:</u> Defining the salmon ecosystem	Salmon and steelhead production can be maintained or increased by focusing management primarily on the freshwater part of their life history. Estuary and ocean conditions are ignored because they are largely uncontrollable.	Restoration and management of wild salmon must address their extended ecosystem and whole life history. This consideration includes human developments, as well as natural habitats.
Scope of Ecosystem	**Freshwater only**	**Entire salmon ecosystem: freshwater, estuary, and marine environments**
<u>Principle 2:</u> Defining the salmon production model	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.	Genetic diversity, life history, and population diversity are the basis of salmonid productivity and contribute to the ability of salmonids to cope with environmental variation that is typical of freshwater and marine environments.
Production Model	**Commodity production focused primarily on single populations in freshwater habitat only.**	**Manage entire salmon-bearing ecosystem (freshwater and marine) and interconnected populations, resulting in stable, resilient production, and long-term persistence.**
<u>Principle 3:</u> Defining the relationship of salmon populations in the ecosystem to one another	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 of another species or population.	Sustained productivity of wild salmon requires a network of complex interconnected habitats, which are created, altered, and maintained by natural physical processes in freshwater, the estuary, and the ocean.
Relationship Among Populations	**Populations not connected**	**Populations and habitats are interconnected**

Implementing the Solution to the Wild Salmon's Problem

Is it possible to change the status quo; to change salmon management and give it an ecological rather than an economic focus? The current approach to salmon management is well entrenched. It will require a major shift in thinking and actions to move to the alternative conceptual foundation. It may also require a crisis, though that appears to be upon us with the precariously low returns of wild salmon and steelhead in 2017 and predicted for 2018 as well.

Changing a person's worldview or an agency's conceptual foundation is not a simple mechanical fix like replacing a malfunctioning part in a machine. It involves changing how individuals think about nature, the resource they are managing, and how that resource should be used. It involves changing long-standing behaviors that are deemed normal and beneficial under the current conceptual foundation. It involves going against a century-old dogma that has successfully resisted change.

Earlier, we described a century of lowered expectations as hatcheries failed to achieve their initial and subsequently revised goals. The sequence of changing goals, expectations, and descriptive terminology follows a pattern described by Thomas Kuhn in his 1970 book, The Structure of Scientific Revolutions. Kuhn described how data that did not fit the commonly accepted assumptions of a discipline were discounted or explained away as long as possible. As the gap between performance and goals became greater, the rationalizations and explanations become more convoluted. Eventually a crisis occurs, in which new insights are generated. A new framework is developed to replace the old. Kuhn describes this process as a paradigm shift.[106]

Impediments to a Paradigm Shift

The current conceptual foundation promotes activities that impede the recovery of wild salmon populations. Four of those activities were discussed earlier. They are:

1. The focus on production of commodities;
2. The shifting baseline syndrome;
3. The failure to recognize the importance of the salmon's strong attachment to place; and
4. The fragmented management of wild salmon-sustaining ecosystems.

These activities and the behaviors that normalize them are impediments to the adoption of the alternative conceptual foundation. We have all heard the justification for continuing these long-standing practices: "Well we have always done it that way."

Another major impediment is the gap between what wild salmon management does and what science is saying it should be doing.[107] We believe the gap persists because salmon managers understand if they were to incorporate the fine-grained approach that current science calls for would call into question many management practices over the last century. The current science can be denied but the impoverished state of wild salmon that results from that denial is hard to escape.

Even if the alternative conceptual foundation were adopted, the irreversibility principle suggests the future of wild salmon, and all aspects of the environment are bleak.[108] Here is the principle: "The cumulative outcome of many decisions within a dynamic system will be dominated by the most irreversible tendencies within human actions regardless of the values people hold."[109] Every day in the Pacific Northwest hundreds, if not thousands of decisions are made that can affect salmon or their habitat. Some of those decisions produce no problems, while others result in problems that are reversible and once they are identified they can be remedied. However, some produce irreversible problems. Once those decisions are made the habitat or salmon population is lost forever.

It should be noted here that the flawed conceptual foundation with its reliance on technology actually enabled irreversible decisions when habitat and wild salmon were traded for hatcheries. Over time, the irreversible decisions gradually accumulate causing habitat to degrade and wild salmon to decline in abundance. The cumulative effects of irreversible decisions are at least partially hidden by the shifting baseline syndrome discussed earlier. The irreversibility principle can produce outcomes that are contrary to the values that we hold. "Irreversible outcomes, each reasonable at some time and place, accumulate to produce a world for our children that few of us would wish on them."[110]

The combination of the irreversibility principle and the difficulty we will face in replacing the flawed conceptual foundation with an ecological alternative dictates the need for bold new initiatives. We propose three initial steps to bring about a paradigm shift in salmon management: 1) Use the public trust doctrine to guide salmon management, 2) create a wild salmon national park, and 3) adopt river and population specific management. Actually, these steps are not new. The public trust doctrine is the product of Roman Law and a wild salmon park was first proposed in 1892.

Salmon Management Guided by the Public Trust Doctrine

The purpose of this section is to give a basic introduction to the public trust doctrine and show the relevance to wild Pacific salmon and their management. Those wanting more information on the doctrine should read Mary Christina Wood's book, *Nature's Trust: Environmental Law for a New Ecological Ag*e. We focused this discussion on information in Mary Christina Wood's book and articles giving the opinions of legal experts on Oregon's interpretation and use of the public trust doctrine. The basic doctrine should be similar in other states in the Pacific Northwest.

Mary Wood used the reasoning from landmark judicial rulings on the public trust doctrine to develop a list of six factors that courts have used to determine if a natural resource deserves protection under the doctrine. Those factors are: 1) public need, 2) scarcity, 3) customary use and reasonable expectation, 4) unique and irreplaceable heritage, 5) suitability for common use, and 6) ancillary function. A resource need only be consistent with one of the factors to be treated as part of the public trust.[111] Wild Pacific salmon are firmly consistent with five of the factors (2-6). We believe they are consistent with the first factor, but, recognize that others could hold a contrary opinion.

The public trust doctrine imposes several duties on the trustee (legislature) and its administrative agencies (fish and wildlife agencies, water resource departments, etc.). For wild salmon, those duties require that managers protect existing salmon, prevent waste, maximize the value of the salmon, restore impoverished salmon populations, and prevent privatizing salmon.[112] In carrying out their trust responsibility, the trustees must have "absolute loyalty to the citizen beneficiaries."[113] Those beneficiaries are present and future generations. The public trust doctrine requires that we pass on to future generations wild salmon in as close to their natural, historical condition as possible. If future generations inherit only salmon produced in a hatchery or severely impoverished, the trustees would be in breach of their responsibility.

Even though Oregon case law has sustained the state's sovereign ownership of wildlife and the applicability of the public trust doctrine, the doctrine is underappreciated in the state.[114] One of the authors (JL) was employed by ODFW for 18 years. During that time, he cannot recall the public trust doctrine being mentioned.[f] It was never a strong element in the agency's fisheries programs. It could have been a useful tool. Since the public trust doctrine is based on the government's, i.e., public's, sovereign ownership of resources it carries greater authority than legislative statute. As such, public trust doctrine can serve as a backstop to environmental law.[115] The sovereign ownership of water, fish and wildlife predates statutes and is independent of them. The courts, legislatures and agencies should take the senior, independent existence of the public trust doctrine into account when interpreting statues and building programs.[116]

Current management fails in its trust responsibility. The failure is most evident in the conflict between salmon management operating under the politics of abundance or the politics of scarcity. This is another way of describing the two missions of salmon management discussed earlier in this report. We recognize that the current, impoverished state of the salmon has many causes. However, we show in this report that the management agencies themselves contributed in a significant way to the salmon's depleted state. Even after the listings under the federal ESA, those agencies have continued the long-standing focus on the politics of scarcity. We will use Mary Wood's description of the politics of scarcity relative to Columbia River salmon:

> *"When regulation under the Endangered Species Act commenced in the early 1990s, instead of truly trying to rebuild the runs as the law requires, federal officials busied themselves with figuring out how much death they could sanction without sending the species over the edge to extinction. Finding that magic line – between not enough death and too much death, not enough destruction and too much destruction, not enough risk and too much risk – describes the work of most environmental agencies today operating under the politics of scarcity."*[117]

The politics of scarcity is the result of a capitalist, market-driven exploitation of

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[f] JL did interview Phil Schneider, a former director of the Oregon Game commission, in 1995. This was after both Phil and JL had left the department. In the interview, Phil expressed a strong commitment to the public trust doctrine. (See page 33)

commoditized salmon. This system demands continuous economic growth and capital accumulation. When fisheries target mixed stocks of hatchery and wild salmon, the level of exploitation is set to come as close as possible to Wood's magic line. This inevitably leads to over harvest of wild salmon and their impoverishment. Salmon management agencies will not shift to the politics of abundance, if the focus of their effort is on the production of commodities with a heavy reliance on hatcheries.

How would wild salmon management differ under public trust doctrine guidelines. First, we (public and salmon managers) must understand that the politics of abundance strives to learn how to manage within the natural rhythms and uncertainty of the natural salmon producing ecosystems. Avoiding those rhythms through technological fixes will, in the end, destroy the ecosystems and their wild salmon. Salmon managers must realize that the current impoverished state of wild salmon is a product of a conceptual framework and a political and economic system based on the rules of capitalist resource exploitation.[118] The public trust doctrine is an anathema to the principles of that system. Our alternative conceptual foundation is the first step towards a management paradigm that adopts the principles of the public trust doctrine.

Creation of a Salmon National Park

A wild salmon national park has several immediate benefits. It would:

- Recognize our obligations to treat wild salmon as a public trust;
- Be a positive step toward a reasonable legacy for future generations;
- Constitute a shield against irreversible decisions within the park boundaries;
- Reduce the effects of the fragmented management of ecosystems;
- Give the recovery of ecological processes and natural production priority over the focus on commodity production;
- Demonstrate the fallacy in the belief that technology always supersedes ecology; and
- Give the staff of management agencies the incentive to think differently about their stewardship responsibilities.

We said the wild salmon national park was a bold new initiative, but the idea has had a long history.[119] In 1892, Livingston Stone gave a prescient speech to the twenty-first meeting of the American Fisheries Society calling for a national salmon park. His passionate speech included this statement:

> *"Provide some refuge for salmon, and provide it quickly, before complications arise which may make it impracticable, or at least very difficult… If we procrastinate and put off our rescuing mission too long, it may be too late to do any good."*[120]

Stone's remarks suggest he sensed the consequences of the irreversibility principle even though he may not have known it by its current name.

There were many calls for the creation of salmon refuges or sanctuaries in the last century. They all failed. Salmon managers chose to rely on hatcheries and ignore the benefits of a system of salmon refuges. During the same time federal waterfowl managers were building a system of refuges for migratory waterfowl.[121] The salmon managers decision is another example of how the reliance on hatcheries contributed to a detrimental decision that has not been reversible for most of a century.

The life cycle of wild salmon – their dependence upon widespread networks of rivers and streams – forces us to shift our thinking on what a national park would look like. A block of land set aside for protection (e.g. Yellowstone) would not serve wild salmon well. Instead, we need to imagine a connected network of streams and rivers throughout the Pacific Northwest with different levels of protection. The protection given to streams and rivers in undeveloped areas would be different from the protection provided along city greenways. What matters is the effort to integrate appropriate protections over the range of rivers and streams that salmon depend on.

Much of this effort would give coherence to fragmented institutional actions that currently occur (e.g. Corps of Engineers mitigation sites). Some efforts would complement actions taken for other reasons (flood way zones). With the salmon as our guide, a wild salmon national park would provide coherence to a wide range of otherwise fragmented actions. It would demonstrate that, with creative effort, a whole can be more than the sum of its parts. And it would provide a legacy for generations to come.

We believe it is not too late to create a wild salmon national park. We also believe, for the reasons stated above, it is a critical step toward the recovery of wild salmon. We do not see a path to the recovery of wild salmon that does not include the creation of a wild salmon national park.

River and Population-Specific Management

On page 16, we discussed the importance of the salmon's attachment to the specific stream reach or tributary where they were born. In spite of its importance, managers failed to adequately consider the salmon's attachment to place in their programs. Hatcheries produce ecologically placeless salmon and harvest of mixed stocks of salmon is placeless management.[122] In this section, we revisit this problem and offer a solution. First, we need to dig a little deeper into the salmon's connection to place.

Compared to other fishes, Atlantic and Pacific salmon are among the most population rich (Figure 2). To understand why, 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 dispersing to the same stream reach or tributary where it was born.[123] These local breeding groups, when physically isolated from other groups during spawning, fit the common definition of a population. Reproductive isolation and the return to the same place to spawn generation after generation adapts the population to the environmental conditions of its home stream reach or tributary. Adaptation leads to genetic and life history differentiation, which is the basis for the population and species' biodiversity. These attributes are so important that it makes the individual salmon population the fundamental management unit.[124] The individual population is what management should be trying to protect and nurture. Some of the salmon populations are very large and some consist of a few hundred

(Decreasing population richness)

Atlantic salmon, Pacific salmon
Atlantic shad
Atlantic cod
rainbow smelt
haddock
Atlantic mackerel
Atlantic menhaden
European eel

Figure 2. Population richness in anadromous and marine species in the northern Atlantic.[125]

fish occupying marginal habitat in a small tributary stream. Thus, the structure of the salmon resource consists of large and small populations whose spawning habitats are spatially, geologically and climatically diverse.[126]

A glance at Figure 2 raises the question: Why are salmon and the Atlantic menhaden at opposite ends of the figure?

The previous paragraph explained the origin of the salmon's population richness. Moving down Figure 2 to the right, each species has progressively less geographical separation among spawning adults with a corresponding diminished number of populations. Species at the lower right corner like Atlantic menhaden are thought to consist of a single population.[127]

Juvenile salmon undertake long migrations through the river to the estuary and into the ocean. To complete their migration and return to their natal stream to spawn, the salmon must pass through and temporarily occupy individual links in a chain of habitats.[128] The population's movement through the chain of habitats is a spatial-temporal pathway through the salmon's extended ecosystem[129] 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.[130] For example, fall Chinook salmon in Sixes River, Oregon follow five different spatial-temporal pathways through the river's freshwater and estuarine habitats[131] and Chinook salmon in the Rogue River, Oregon followed eight pathways.[132] This 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. Life history diversity is how salmon avoid putting all their survival eggs in one basket. This strategy has been called "spreading the risk"[133] and it makes an important contribution to the salmon's resilience in the face of changing climatic conditions.[134] 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, as a whole, to experience stable levels of overall productivity.[135]

A strong attachment to a stream reach or tributary gave rise to population richness. It is the wellspring of the salmon's key biological attributes. Those attributes (attachment to place, biological diversity and resilience) were largely responsible for the rich abundance of salmon when Euro Americans arrived in the Pacific Northwest. Collectively, those attributes are the salmon's solution to the problems of survival and reproduction in variable environments.[136] Salmon management programs that fail to conserve and nurture these attributes are bound to fail.

In its study of salmon and society in the Pacific Northwest, The National Research Council described a large gap between what the public wants, abundant salmon for example, and what they get. Salmon are impoverished, on the brink of extinction and protected by the ESA. The National Research Council said the gap existed because people also want things that conflict with salmon such as perpetual economic growth. Institutions that perpetuate behavioral norms detrimental to the wild salmon are another cause for the gap.[137] We believe there is a third cause for the gap. Over the past several decades, fisheries science has been studying the intimate relationship between wild salmon and the habitats they occupy in freshwater, estuary and nearshore marine waters. We gave a glimpse into this intimate relationship in the preceding paragraphs. Fisheries science has been validating the claim made by Willis Rich in 1939 that the population in its habitat is the fundamental unit of salmon management.

Managing wild salmon at the population level is a fine-grained approach that the management agencies are reluctant to adopt. They prefer the convenience of a coarser grained approach that combines several populations into artificial "management units." The intimate relationship between real populations and their habitat is lost in these artificial "management units." As W. F. Thompson explained on page 17 of this report, whole populations can go extinct without notice when they are members of an artificial "management unit."

Management agencies favor coarse-grained management. Current science calling for a population specific, fine-grained-approach to management is not incorporated into their programs.[138] Managers know that science is telling us to take a finer-grained approach to the conservation of wild salmon, but they are reluctant to do so. A management paradigm that nurtures individual populations and habitat in their birth streams would call into question the basic approach management has taken for the past 130 years. It would destroy the comfort of the status quo.

We believe wild salmon management must

begin the transition to river and population specific management. It will be difficult for agencies that have been focusing on the production of commodities, but they can no longer afford to ignore scientific reality. The survival of wild salmon as climate change progresses will depend on the health, biodiversity and resilience of individual populations.

Salmon 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. This approach to management is already in place for many Atlantic salmon populations and rivers. Atlantic salmon (Salmo salar) have undergone a long-term decline in both populations and overall productivity.[139] In 1998, the North Atlantic Salmon Conservation Organization (NASCO) agreed on a precautionary approach to salmon fisheries management aimed at maintaining all populations above their conservation limit – the number of female salmon below which recruitment starts to decline significantly.[140]

Norway, for example, has adopted a reference point-based management that is essentially what we call river and population specific management. Norway is a core country for Atlantic salmon, with approximately 25 percent of the world's healthy populations spread across 439 populations.[141] Conservation limits (female escapement numbers) were established for all 439 Norwegian self-reproducing Atlantic salmon populations during 2007–2009 and evaluated against salmon return statistics from 2009–2011. In 2011, the populations were at 95 percent of their female escapement goals, compared to 91 percent in 2009, and 85 percent in 2005. The authors conclude that the use of conservation limits and management targets resulted in success in meeting the primary goal of protecting the Norwegian salmon populations and ensuring that an increasing number of populations are at their maximum reproductive capacity. The secondary goal of increasing fisheries yield for stakeholders has not yet been shown but is expected as the program matures.[142]

The basic elements of river and population specific management are:

- Develop escapement targets for the wild populations of each species to achieve egg deposition and parr production goals. Monitor compliance with those targets.
- Develop and protect a habitat template that supports adult holding and spawning, juvenile rearing and a diversity of life histories.
- Prevent interbreeding between hatchery and wild fish.

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

Recommendations

Salmon management can be divided into activities that fall into three categories: harvest, production and habitat. We will discuss here the consequences for each category resulting from a switch to the alternative conceptual foundation. Two concepts drive the recommendations we provide below:

- We will shift the burden of proof from wild salmon to the activity that threatens them. Managers will not have to prove damage to wild salmon or their habitats in order to forestall a potentially detrimental activity; the proponents of a threatening activity will have to prove it is safe.
- We will shift the focus of wild salmon management from the current coarse-grained approach to a fine-grained approach.

Recommendations are presented in bold type.

Harvest

Adopting the alternative conceptual foundation will require a change in where the salmon are harvested, how many salmon are harvested, and the rationale for determining both of those. Since the widespread use of gasoline or diesel engines in fishing craft, the bulk of the fishery moved offshore where it harvests salmon from a mixture of stocks from different rivers. Small populations or populations with low productivity are driven to extinction when continually overharvested in these mixed-stock fisheries.[143] It's difficult to regulate the harvest of individual populations in a mixed-stock fishery. So, achieving adequate escapements for all the wild populations in the fishery is more a matter of luck than effective management. This is coarse-grained management. The alternative, fine-grained management, recognizes the individual population and its watershed as the fundamental conservation unit.[144] Spawning escapement targets must be set for each population and watershed.

Part of the fisheries harvesting mixed stocks of salmon must move away from those areas and relocate close to the home streams where the catch must be monitored to ensure adequate river and population-specific escapements.

No offshore harvest or main stem harvest in large rivers will be allowed until it can be determined what populations compose the fishery.

The offshore fisheries will be curtailed until their proponents can prove that they can be regulated to achieve all the escapement targets for the individual populations they harvest.

Production

Hatcheries. Harvest and hatcheries are intimately linked. Biologist Phil Mundy succinctly summed up one troubling consequence of that linkage:

> *"The willingness to sacrifice vulnerable wild salmon stocks in order to harvest the bountiful hatchery returns of 2001 to 2003 and especially 2002, follows a long-established harvest management formula that has frequently led to disaster for conservation of wild salmon stocks in the Columbia River and elsewhere in the Pacific Northwest …."*[145]

The purpose of a hatchery is to supply commoditized salmon to the sport and commercial fisheries.[146] Harvest has traditionally been set to maximize the catch of salmon produced with the public's tax and license dollars. Anything short of the maximum harvest of hatchery fish creates wasted salmon and wasted tax dollars. This is a reasonable way to look at the use of hatchery-produced commodities, until the target of the fishery is a mixed stock of hatchery origin and wild fish. Then the regulation of harvest to maximize the catch of hatchery fish can lead to over harvest and extinction of the wild salmon as Phil Mundy clearly states.

Where a fishery is targeting a mixture of wild and hatchery-origin salmon, the harvest manager must give priority to ensuring an adequate escapement of all wild salmon populations to their river-specific spawning areas.

For several years, biologists have expressed concerns regarding the impact of hatchery operations on wild salmon[147] and concern regarding the principles that underlay and govern hatchery programs.[148] These concerns led to several reviews and evaluations of hatchery programs by independent scientific panels.[149] All of the reviews of salmon hatchery programs produced several recommendations to improve the operation of hatcheries and reduce their negative impact on wild salmon. However, in our collective experience, we have seen little change or even recognition by management agencies that those recommendations exist. A change in accountability in hatchery operations is long overdue.

The state and federal agencies and private corporations must within five years produce for each hatchery or aquaculture operation, peer reviewed evidence of no negative effect on wild salmon. Any hatchery that fails to meet this standard should be closed.

Natural Production. Salmon management has, for well over a century, been practiced on the cheap. This coarse-grained approach aggregated several populations into management units, simplified the production process by eliminating or reducing the importance of ecological processes and relationships, and focused on commodity production using hatcheries. This approach ignored the salmon's genetic and life history adaptations to their natal habitats and environments. Managers superimposed this course-grained approach on natural production systems causing them to degrade. Wild salmon management remained at a coarse scale in spite of evidence that it needed to take into account the fine scale processes and relationships of the salmon-sustaining ecosystems.[150] The result has been a failure in the current management system.[151]

Salmon management must adopt a finer-grained approach to wild salmon production, one that recognizes the individual population in its natal watershed as the basic management unit. This has been referred to as river and population-specific management. It will entail a shift in performance measures from those focused on commodity production, to the salmon ecosystem vital signs discussed earlier.

Habitat

The fragmented management of ecosystems in the Pacific Northwest made it difficult for salmon managers to provide an adequate level of habitat protection. Managers often use this fragmentation to avoid the difficult task of protecting salmon habitat, especially when it involves being critical of habitat degrading practices of another government agency. What can the salmon manager do to protect critical salmon habitat in this situation? We answer this question by giving the opinion of one of the past leaders of fish and wildlife management.

Philip Schneider was the director of the Oregon Game Commission from 1951 to 1969. The Game Commission later became the Oregon Department of Fish and Wildlife. He also served on the Oregon Fish and Wildlife Commission. Jim Lichatowich interviewed him on August 10, 1995. Phil is known for his steadfast opposition to Pelton Dam on the Deschutes River. He sued to stop the dam and took the suit all the way to the United States Supreme Court. He did this against the wishes of the Governor of Oregon and the legislature. The part of the interview given here is about his basic philosophy and how he viewed his public trust responsibilities and why he refused to give up on the salmon above McNary Dam when the Department of Interior had written them off.[152]

> *"Yes, I am of the philosophy, as a member of the [Fish and Wildlife] Commission, I regard this as a public trust. That's the only reason, the only justification, for the existence of the Commission. As a trustee for the resource which [is] a common property resource… I just don't think that one has, in that kind of responsibility, the right to trade off the resource. Whether you win or lose, I don't think you have that kind of right." (See footnote f.)*

> **Salmon management agencies must accept their public trust responsibilities from the leadership down to the field biologist and hatchery staff.**

When one takes in the full scope of the impoverishment of wild salmon and the narrowly focused current conceptual foundation that contributed to it and compares that to Phil's record and his statement above, you get a sense of how far our profession has gone in the wrong direction. To protect habitat and rejuvenate the salmon ecosystem vital signs, we need leaders in our state and federal agencies that will embrace their public trust responsibilities, and like Phil, put their jobs on the line. Without that kind of leadership, the management agencies will continue the dysfunctional behaviors discussed in this report and the wild salmon will continue to decline.

5-Photo courtesy of Thomas Dunklin. Wild king salmon.

A Brief Summary of Salmon Management in the Columbia River

In this section, we illustrate how the current conceptual foundation has shaped salmon management in the Columbia Basin. Because the Columbia River is the largest river basin in the Pacific Northwest, a closer examination of its history and management is warranted. The story that emerges is also a surrogate for many other salmon producing systems. Earlier in this report, we discussed detrimental behaviors and practices that are sanctioned by the current conceptual foundation. Here we will show the consequences of three of those practices: A reliance on technology that keeps recycling failed restoration practices, fragmented management of the salmon-sustaining ecosystems, and management that focuses on commodity production. We end the section with a discussion of the listings of salmon in the Columbia River under the federal ESA.

Recycling of Failed Solutions to the Salmon's Problem

Early in this report we stated that resolving the wild salmon's problem has proven elusive because managers recycle past solutions that have questionable performance records. We also stated earlier that salmon managers tied to the failed dogma of hatcheries would, when the failure became too obvious to ignore, simply reinvent the hatchery with a new mission and with updated terminology. We gave a brief history of those reinventions on pages 10 and 11. That history also applies to the problem of recycling solutions with questionable performance records.

When the construction of mainstem dams began hatcheries were reinvented as a way to mitigate for the loss of salmon. However, there was enough concern over the ability of the hatcheries to compensate for the effects of the dams that in 1938 the Secretary of Interior appointed an independent Board of Consultants to evaluate the mitigation plans.

The Board recommended that hatchery mitigation for dams be treated as an experiment and cautioned salmon managers that because it was an experiment, there was the possibility of failure. They added: "...The adoption of the plan for trial should not be understood as implying an indefinite commitment to its support, but only for so long as the results may reasonably appear to justify its continuance."[153] To treat hatchery mitigation as an experiment was a significant event. The dogma would finally be evaluated and held accountable.

In 1999, sixty years after the Board of Consultants tagged the mitigation plan as an experiment, concern over the failure of hatcheries to fully mitigate the effects of the dams prompted the Northwest Power Planning Council to undertake a review of hatchery mitigation in the Columbia River. The result was a set of policies regarding the use of hatcheries in the basin and a plan to reform hatchery operations. One of those policies struck a familiar note: "Artificial propagation remains experimental. Adaptive management practices that evaluate benefits and addresses scientific uncertainties are critical."[154]

Because the Council didn't recognize the earlier failure to follow through on the experimental approach, it didn't take the steps needed to ensure that its policy was actually carried out. Four years after the policy was approved the Independent Scientific Advisory Board conducted a review of supplementation hatcheries. The board concluded that supplementation was being implemented in a way that makes comprehensive evaluation unlikely.[155] This created the strange situation where not only was the hatchery solution to the salmon's problem recycled, but periodically, scientific reviews of artificial propagation were also recycled. Neither achieved their purpose.

The council did not understand the power of the status quo to enforce the hatchery dogma and ensure adequate evaluation was not carried out. And so here we are in the twenty-first century armed with a tool that has a record of failure and an uncanny ability to reinvent itself for every situation.[g]

Fragmented Management of Ecosystems

The fragmented management of wild salmon-sustaining ecosystems has evolved into a convoluted institutional mess that the Snake River Salmon Recovery Team called "jurisdictional chaos."[156] Fragmented responsibility for the management of wild salmon-sustaining ecosystems makes it extremely difficult to mount an integrated, whole life history or whole ecosystem restoration program. A recent event illustrates this problem.

After spending 53 million dollars to develop an ecosystem approach to the management of 71 million acres of federal land in the interior Columbia Basin, the program fell apart in the early stages of implementation. A fragmented institutional structure and conflicts among special interest groups prevented the parties from reaching a binding agreement on how the program should be implemented.[157] According to an article in the Portland *Oregonian* the failure of the interior Columbia Basin plan may have killed an ecosystem approach to the management of federal lands.[158]

The plan is not being implemented within an ecosystem context as originally intended. However, the federal agencies involved are independently using the scientific assessments to implement parts of the plan. The inability of the various parties to the plan to reach agreement on its implementation is a bleak sign for the future of salmon recovery. Long migrating species like Pacific salmon require whole ecosystem and whole life history approaches to restoration, but clearly, such an approach is going to be difficult to implement within a fragmented institutional structure and the special interest conflicts it creates. Humans constrained by the current conceptual foundation and a fragmented ecosystem have not been able to imagine or implement an institutional structure capable of managing salmon at the scale of their extended ecosystem.

[g] A recent example of this occurred in Washington State. In 2012-2014, two large dams that blocked salmon migration were removed from the lower Elwha River on the Olympic Peninsula. Removal restored access for remnant runs of five species of Pacific salmon and steelhead trout into more than 40 miles of nearly pristine habitat of the upper Elwha watershed. More than 80 percent of the Elwha watershed was protected for nearly 100 years inside Olympic National Park. In spite of the unique opportunity to observe how quickly remnant wild salmon and steelhead might recolonize and rebuild their populations in a nearly pristine watershed, managers chose to use hatchery programs to rebuild the Elwha Basin salmon populations. It was labelled an ecosystem restoration program.

Salmon Management's Focus on Commodity Production

In both 1985 and 1986 one coho salmon crossed Lower Granite Dam in the Snake River. In 1987, none returned. The coho run into the Snake River tributaries blinked out of existence.[159] This is an example of the consequences of mixed stock salmon fisheries described in the quote by W. F. Thompson on page 16. Those mixed stock fisheries are managed to maximize the harvest of hatchery-origin salmon, which reflects the focus on commodity production. Wild populations are sacrificed to "… an often over looked industrial giant."[160] Before the endangered species listings, this approach was considered normal and was built into management plans. The following quote is from Oregon's 1982 Comprehensive Plan for Production and Management of Oregon's Anadromous Salmon and Trout: Part II Coho Salmon Plan:

> *"Management of coho within the Columbia River system, while emphasizing hatchery production, will attempt to maintain self-sustaining natural populations, if possible. Although management strategies will be directed towards harvesting hatchery surpluses, these same strategies will not overlook possible ways of protecting wild spawners. Furthermore, every effort will be made to optimize natural production by selecting and liberating appropriate hatchery-reared stocks in underutilized streams."*[161]

In spite of a section defending the need to protect wild salmon, this paragraph illustrates the way the current conceptual foundation normalized behavior that created three of the problems discussed earlier. The role of hatcheries was reinvented to solve a problem that hatcheries created. Hatchery-reared fish would be used to stock underutilized streams. The streams were underutilized because harvest on mixed hatchery and wild stocks overharvested wild fish. Dams and other habitat degradation imposed another significant source of mortality on wild salmon. This was facilitated by the managers' willingness to trade hatcheries for habitat. The quote from the Oregon Coho Plan is an example of coarse-grained management. It reflects a management focus on commodity production and harvest while largely ignoring the ecological process wild salmon depend on.

When Oregon wrote its Coho Management Plan in 1982, the extinction of Snake River coho salmon in 1986 was probably inevitable. However, the approach to management that the plan put into writing was consistent with the current conceptual foundation, which had been guiding management for close to a century. That conceptual foundation normalized ideas and behaviors detrimental to wild salmon in the Columbia River and elsewhere throughout the Pacific Northwest. The listing of Columbia River salmon under the Federal ESA should have forced a reassessment of salmon management. In the next section we discuss if that reassessment has taken place.

ESA and Salmon Management in the Pacific Northwest

The Columbia River drains an area approximately the size of France and has two major tributaries, the Snake River in southern Idaho and eastern Oregon, and the Willamette River in western Oregon. Historically, it supported estimated annual salmon runs of

10–16 million fish that included five species of Pacific salmon and steelhead trout. Current run sizes average about 1.5 million fish (from 2000–2006), although about 80 percent of those are of hatchery origin. Thus, annual runs of wild salmon and steelhead presently average about 300,000 fish – about 2.5 percent of historical wild fish abundance.

Snake River sockeye salmon were listed under the federal ESA as endangered in 1991. This was followed within a decade, by the listing of 11 additional Evolutionary Significant Units (ESU) of Columbia River salmon and steelhead, and two resident species, bull trout and Kootenai River white sturgeon.[162] An ESU may contain several populations. The listed salmon and steelhead ESUs in the Columbia River contain 190 populations.[163] Federal actions designed to recover listed salmon and steelhead populations have been mired in a continuing series of legal challenges and no salmon or steelhead population has recovered enough to warrant delisting.[164]

The Snake River Basin is the major upstream salmon-producing tributary in the Columbia River Basin. The importance of Snake River salmonid production cannot be overstated with respect to life history types and diversity. Declines of Snake River salmon occurred over decades, but, accelerated starting in the 1960s. Estimated annual returns of spring/summer Chinook declined from 125,000 fish in 1950-1960 to just 12,000 fish in 1979.[165] By 1994, their run size was estimated at less than 2,000 adults. Snake River fall Chinook numbers fell to 78 fish in 1990, and Snake River sockeye salmon to less than ten adults per year, with only a single fish returning in 1992.[166]

These precipitous declines initiated a period of ESA listings for salmon populations first in the Snake River, then the Columbia River, and finally across the whole Pacific Northwest. Currently, 28 salmon and steelhead ESUs are under ESA protection across the Pacific Northwest. Recovery plans and other biological assessments developed by NOAA Fisheries to guide salmon and steelhead recovery have been repeatedly challenged by a coalition of environmental groups and have been consistently rejected by federal courts, primarily because they do not reflect current scientific understanding of salmon life history and ecology.[167]

The ESA protects species against actions called “take” that cause jeopardy, harm, or kill members of a listed ESU. Federal agencies proposing actions that may have an effect on ESA-listed salmon or steelhead are required to consult with NOAA Fisheries. Operation of the Federal Columbia River Power System (FCRPS) poses a risk that requires consultation. The FCRPS is operated by the US Army Corps of Engineers (Corps), Bureau of Reclamation (BOR), and Bonneville Power Administration. These Action Agencies develop biological assessments, describing their proposed operating plans for the FCRPS and potential effects on ESA-listed salmon. NOAA Fisheries reviews these assessments and renders a Biological Opinion (BiOp), to ensure that the proposed actions will not reduce the likelihood of survival and recovery of ESA-listed species.[h]

[h] A BiOp usually also includes conservation recommend-dations that further recovery of the specific ESA-listed species, including reasonable and prudent alternatives as needed to minimize any harmful effects. A biological opinion is not an ESA recovery plan, but may serve as a component of a recovery plan.

The first recovery plan for Columbia River ESA-listed sockeye salmon was issued in 1995. NOAA Fisheries also prepared a BiOp in 1995 that evaluated the impacts of hydropower operations on the endangered sockeye salmon. Environmental groups mounted a legal challenge to the BiOp. From 1993 to 2017, NOAA Fisheries released a series of eight separate BiOps designed to provide management actions offsetting jeopardy to listed salmon populations caused by the hydro system. Each of the BiOps have been challenged by a coalition of environmental advocates and all but two have been overturned in federal court.

This quote from Judge Simon's 149-page opinion reflects his frustration with the federal agencies' status quo approach:

> *"For more than 20 years, NOAA Fisheries, the Corps, and BOR have ignored the admonishments of Judge Marsh and Judge Redden to consider more aggressive changes to the FCRPS to save the imperiled listed species. The agencies instead continued to focus on essentially the same approach to saving the listed species – minimizing hydro mitigation efforts and maximizing habitat restoration. Despite billions of dollars spent on these efforts, the listed species continue to be in a perilous state. ...The FCRPS remains a system that 'cries out' for a new approach. A NEPA process may elucidate an approach that will finally move the listed species out of peril. ...The 2014 BiOp continues down the same well-worn and legally insufficient path taken during the last 20 years. …It also fails adequately to consider the effects of climate change and relies on a recovery standard that ignores the dangerously low abundance levels of many of the populations of the listed species."*[168]

Status reviews of the Columbia River listed salmonids were conducted recently by NOAA Fisheries and released in 2016. The reviews supported continued listing for all Columbia River ESUs. Thus, 26 years after the first listing in the Columbia River, all 13 ESUs remain under ESA protection. The status reviews found that the same suite of causes that led to the decline and listing for the populations, continue to impede their recovery.[169]

The fulcrum for initiating change in the management of wild salmon in the Pacific Northwest lies, in our view, with the conceptual foundation that guides the behaviors, practices and policies of management agencies. The continuing failure of the federal planning and recovery effort for Pacific Northwest salmon is a result of the chasm that exists between the current conceptual foundation's production system and an alternative conceptual foundation based on the salmon's ecological and life history needs. This incompatibility lies at the root of the Court's consistent rejection of a series of BiOps for Columbia River salmon over the past 25 years. While some aspects of an alternative conceptual foundation, first articulated by Williams and colleagues,[170] have been incorporated into recovery efforts (see the example below), the major thrust of current management actions proposed in both recovery plans and BiOps remain rooted in the industrialized production system of the existing conceptual foundation.

Okanagan River/Osoyoos Lake Sockeye: A Non-Traditional Mitigation Measure

Sockeye salmon are one of the five salmon species in the Columbia Basin. They have a unique life history among salmon species due to their use of lakes for the freshwater rearing of juveniles. Historically, at least 27 lakes originally supported populations of Columbia River sockeye in Oregon, Washington and Idaho.[171] Sockeye now occur in the Columbia River Basin in only three localities: Lake Wenatchee, Washington; Lake Osoyoos, Washington and British Columbia; and Redfish Lake, Idaho. The Idaho Snake River sockeye ESU is listed as endangered.[172]

Here, we describe a recent ecological and life-history based management program for Osoyoos sockeye salmon. Over the last 15 years that approach led to a dramatic ten-fold increase in sockeye abundance in the Okanagan River Basin. Two key points to keep in mind are: the spawning area for Osoyoos sockeye lies above nine dams in the upper Columbia River and artificial propagation plays a minor role in the recovery effort. Hatchery fish make up 10 percent of the adult returns. The rapid increase in sockeye abundance demonstrates the power and recovery potential of salmon when managed using a conceptual foundation that incorporates their ecological and life history needs.

The Okanagan River/Osoyoos Lake Sockeye Program was characterized as "a non-traditional mitigation measure" in the Columbia River.[173] It was initiated with life history studies of the Osoyoos Lake sockeye and the identification of ecological factors that limit survival during that part of their life cycle spent above the nine main stem dams. In 1999, following a review of the capacity of spawning habitat, the escapement target was increased from 38,900 to 58,730 spawners with provision to increase to 135,471.[174] Then a Fish-Water Management Tool (FWMT) was developed. The FWMT is a decision support model that helped managers reduce density independent mortality on eggs and fry. Implementation of the FWMT reduced the incidences of flow deviations that led to redd desiccation/freezing, redd scouring, and reduced availability of spawning habitat. The FWMT has also prevented expansion of the anoxic conditions in Osoyoos Lake that reduced the rearing habitat available to juvenile sockeye salmon.[175]

Once the FWMT was implemented in water year 2005, juvenile sockeye production jumped from an average 300,000 a year to 3 million with a high of over 8 million.[176] Then three years later (2008), the number of adult sockeye salmon underwent a dramatic increase in abundance with 213,607 fish crossing Bonneville Dam – the lowest dam in the Columbia River. This higher level of productivity has continued through 2014 with 614,179 sockeye salmon counted at Bonneville (Figure 3). The Osoyoos sockeye make up about 80 percent of the counts of sockeye salmon at Bonneville Dam.

Several factors contributed to the increase in natural production of Osoyoos sockeye salmon. Improved survival passing the main stem dams and improved ocean conditions were factors. They could not have been the main cause, because they did not lead to dramatic increases in other salmon populations throughout the basin. Instead, it appears the main causative factor was the "non-traditional mitigation measure" implemented in the Osoyoos. The FWMT shows how technology was used to inform management and boost Osoyoos sockeye runs. In this example, technology (the FWMT) was embedded in a conceptual foundation based on the salmon's natural life history and knowledge of the ecological constraints on survival. That approach

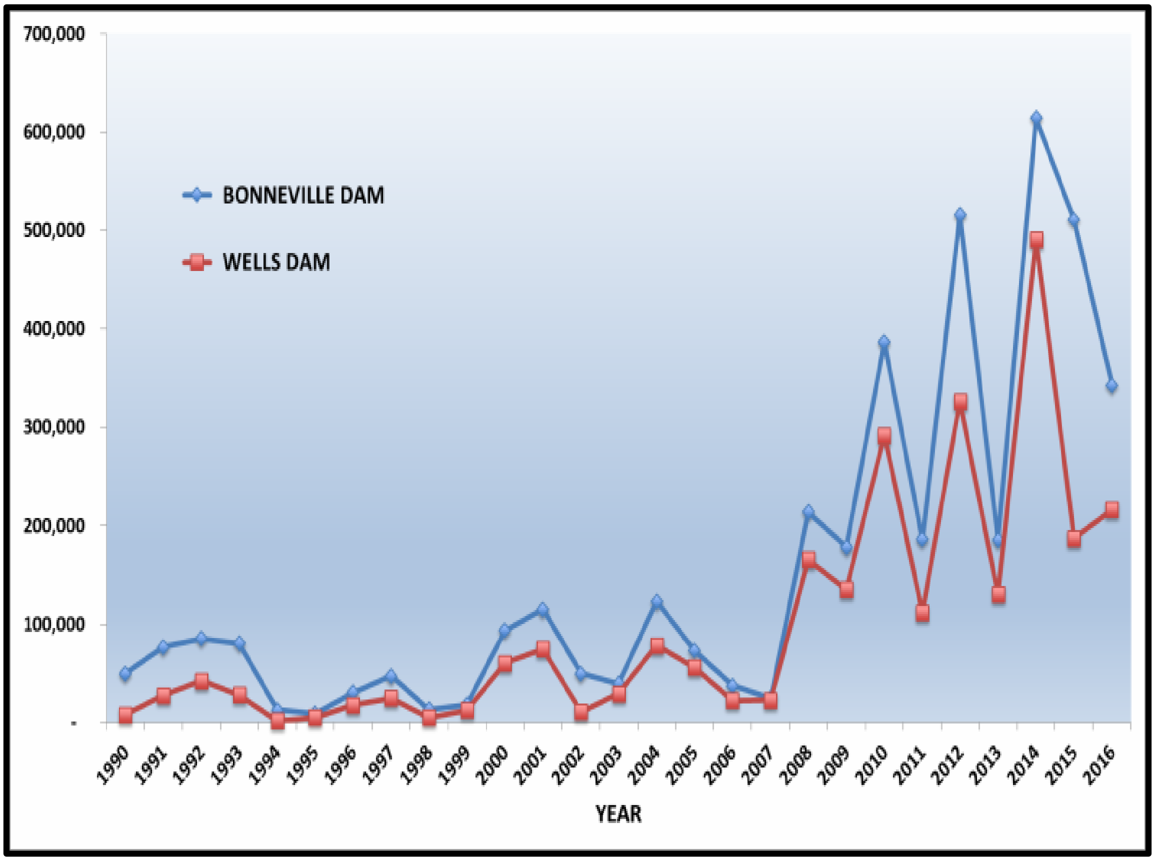


Figure 3. Abundance of adult sockeye salmon entering the Columbia River (blue line) and the abundance of sockeye headed for Okanagan/Osoyoos Lake (red line), 1990-2016.[177]

focused on restoring ecosystem linkages and the sockeye's inherent productive capacity instead of the more conventional approach that circumvents those linkages with artificial propagation.[178]

The Columbia River Debut of Climate Change

Climate change is a subject of great importance for the Pacific Northwest, the country and the earth. It will affect wild salmon and the rivers of the Pacific Northwest. Yet even if you have an interest in climate change and its consequences, it's difficult to penetrate the fog of misinformation and outright lies. Complicated scientific climate models are difficult to understand if you are not a climate scientist. Climate change hasn't risen to the level of concern it deserves in our national agenda because visible evidence has been slowly accumulating in the lower 48 states. Sure, we have experienced increasing frequency and size of forest fires in the west, increasing frequency of major storms with massive destruction and an almost continuous stream of record setting temperatures. However, these events are interspersed with more normal climatic conditions allowing politicians to focus their attention elsewhere. Another reason is the strategy used by the climate scientists. They believed that knowledge would act as a forcing function. Once the science was known it would force action, but the forcing function of knowledge ran up against the dogma of perpetual economic growth.[179] In an earlier section, we described how economics can dominate and overrule ecological reality.

It's hard to get a feel for what is in store for us in just a few decades, that is, it was hard until 2015. In 2015 the fog lifted just a little and gave us a peek into the future. If you were paying attention and if you worry about wild salmon, 2015 was a harbinger of bigger problems to come. 2015 was a record-breaking year around the world. Global surface temperature rose to the warmest ever recorded and that was accompanied by records for ocean heat content, sea level and loss of sea ice.[180]

A large part of the Columbia and Snake basins have been converted to reservoirs. Restructuring the Columbia from river to reservoir, especially the storage reservoirs in the upper basin, produced a 50-year trend in earlier spring warming of the river below Bonneville Dam.[181] The warming continued even after the last of the storage reservoirs came on line in the 1970s suggesting the influence of long-term climate change.[182] But something that plays out over a 50-year period is easy to overlook. The combination of reservoirs and the early effects of climate change primed the Columbia River for disaster when 2015 arrived. Sockeye salmon were affected more than other salmon because they migrate during summer. The sockeye salmon from the Okanagan/Osoyoss restoration program discussed in the previous section were hit hard. Of the 475,000 sockeye salmon headed for the Okanagan/Osoyoos that crossed Bonneville Dam, just 2 percent survived to reach their spawning grounds. Only 1 percent of the sockeye heading for the Snake River and Idaho's Sawtooth Valley reached their destination.[183]

2015 was an unusual, record-breaking year. It may also be the tipping point. The point at which radical change in the climate became more than a far-off possibility. It became a certainty.[184] In spite of all the writing and talking about climate change over the past 20 years, 2015 caught salmon managers unprepared. Ritchie Graves, chief of the hydropower branch of NOAA Fisheries, said "we probably talked too long. The management community probably needs to act more quickly."[185] It might have saved some fish. 2015 was a serious expression of climate change that arrived earlier than the salmon managers expected. In August 2015 NOAA Fisheries published a climate science strategy. Now the question is, will President Trump allow NOAA Fisheries to implement that strategy?

How close are we to more devastating effects of climate change? Can we avoid taking preventative action with the idea it is still many decades away? Those two questions are at least partially addressed in the following discussion of recent information on climate change. Dr. Anthony Ingraffea is a member of a Cornell University's research team that discovered methane leaking from shale gas fracking could be worse for the climate than coal.[186] In a recent lecture, Dr. Ingraffea outlined the consequences of those leaks and the massive use of fracking. Climate scientists had predicted that world temperature would rise by 1.5 degrees centigrade (2.7degrees F) by 2040, Dr. Ingraffea said we are nearly there now. Global temperature might rise to 2 degrees centigrade (3.6 degrees F) in ten to fifteen years.[187] This is very sobering information.

Two historians of science also gave us a partial answer to the question of when to expect devastating climate change. Naomi Oreskes and Erik Conway wrote a small but powerful book on climate change: *The Collapse of Western Civilization: A View from the Future*. The book looks at climate change from the prospective of a historian of science writing the history of how the world failed to act and the consequences it suffered in 2093 as western civilization collapsed. After the discussion of the known facts covering the years from 1970s to the present, the authors use fiction to tell the rest of the story to 2093. Telling a fictional story gave them latitude to make the narrative interesting, while remaining true to what science is telling us could really happen. The book is worth reading, but we want to focus here on one event in the year 2023. That was the first of what the book called "perpetual summers." According to the story the perpetual summers had major catastrophic consequences across the world. Soon after this first one, perpetual summers became the new normal.[188] 2023 is five years away. If the two science historians are correct, wild salmon are in for a very rough time very soon.

The time to begin changing management practices to give the salmon the best chance to survive climate change was 40 years ago, when fisheries research was beginning to discover the importance of biodiversity and the fine-grained web of ecological relationships that sustain the salmon. We will shortly be facing unique twenty-first century problems brought on by the leading edge of climate change. We will be facing those problems with approaches to salmon management based on nineteenth century assumptions. We now have little time to waste. The changes proposed in this report need to be implemented now.

The Road Ahead

In his book *Chicago*, the Portland, Oregon writer Brian Doyle tells us that the way to kill a people is to kill their stories. We believe the same is true for wild salmon and any living creature. For well over a century our management has been killing the wild salmon's story. The basic narrative of their story, the web of ecological relationships that sustain wild salmon, was picked apart by an economy that only valued natural resources that could quickly be converted to cash. Wild salmon habitat and the ecological relationships it supports had no immediate cash value. Habitat was traded for hatcheries and in the hatchery, the last remaining fragments of the wild salmon's story were stripped away, traded for incubation trays and concrete ponds. Making ecologically placeless salmon cut off from their story became a large industrial enterprise. Most industrial enterprises inflict mortality on local native fauna and flora. The most obvious is the road kill we see along the highways. Wild salmon are the road kill of the industrial production system, the system of hatcheries.

In this report, we described the salmon's problem and offered a solution. Our solution, when reduced to its fundamental essence is this: We, meaning the broader we as the public, must return the wild salmon's story and nurture it back to health. That won't be easy for the reasons we describe in this report.

If we are to leave future generations a legacy of wild salmon, it will require a major push by the concerned public to insist that management policies, activities and normal behaviors be changed. The public already suspects there is a need for change in how we manage and recover salmon. A poll taken by the Portland Oregonian in 1997, illustrates this.[189] The poll documented that the public believes salmon are important – 85 percent of those polled said the salmon were very important or somewhat important. Sixty percent said that the recovery programs in the Columbia River were ineffective, yet they were willing to continue spending money on the recovery attempt. This report speaks to that group. It gives them the causes for the failure of current efforts and a way to achieve better results. Another interesting finding was the response to the question why do you want to save the salmon? The respondents had seven reasons to choose from. Here are their responses:

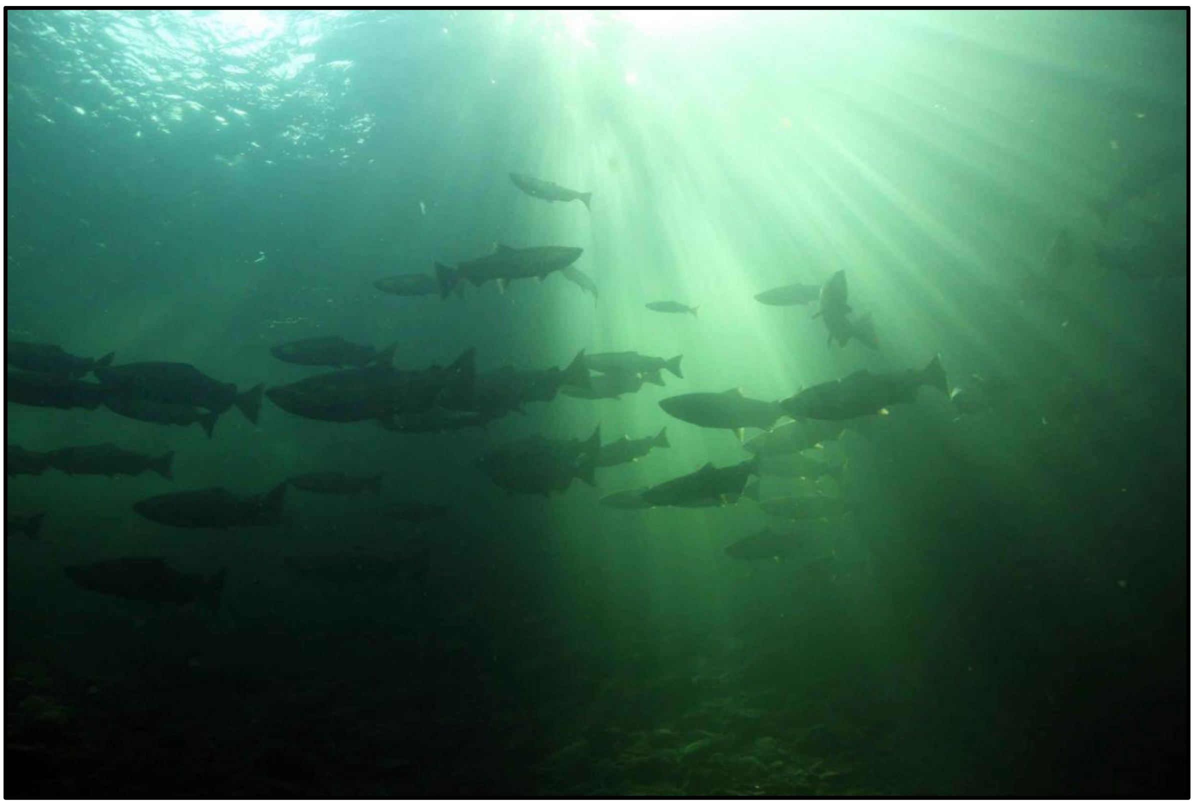
- Because they are part of the Northwest's history and heritage – 36%
- As a gauge of water quality and the environment's health – 35%
- For sport fishing – 9%
- Just to know they are there for personal or aesthetic reasons – 8%
- For commercial fishing—6%
- I don't care about preserving salmon runs – 2%
- Don't know/no response – 4%

The big surprise is the low scores for sport and commercial fishing. Seventy-nine percent wanted salmon saved for reasons other than utilization—for reasons that would fall into the public trust and legacy categories discussed in our report. The poll shows that the region's fish and wildlife management agencies, with their emphasis on utilization and commodity production is out of step with the way the public values salmon.

Is there a future for wild Pacific salmon in the Pacific Northwest? There can be, but it is up to all of us concerned about these magnificent animals to force a change in the status quo, to hold accountable the elected officials and public servants charged with salmon stewardship, and to join in and support those organizations who speak truth to those in power.

6- Photo by Paulette Lichatowich. Salmon carcass.

If the region is serious in its desire to
restore wild Pacific Salmon,
the status quo is not an option.[190]



7-Photo courtesy of Thomas Dunklin. Illuminated salmon.

About the Authors

Jim Lichatowich, who is the main author, has been a fishery biologist for 45 years working in salmon research and management. He is the author of two award-winning books: *Salmon without Rivers: A history of the Pacific Salmon Crisis* and *Salmon*, *People and Place: A Biologist's Search for Salmon Recovery.* In 2015, he received the Life Time Achievement Award from the Oregon Chapter of the American Fisheries Society.

Rick Williams is a Research Associate in the Department of Biology at the College of Idaho and has worked on Columbia River salmon recovery issues since the 1980s serving on numerous scientific review panels. In 2006, he and colleagues wrote *Return to the River: Restoring Salmon to the Columbia River*. He serves as a Senior Conservation Advisor for Fly Fishers International.

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Jim Myron, since 1989, has been an independent contract lobbyist working on natural resource related issues. He focuses on native fish protection and restoration, as well as, water policy and river health issues. He was a policy advisor to Governor Ted Kulongoski and the Legislative Coordinator for the Oregon Parks and Recreation Department.

David Bella is Professor Emeritus of Engineering at Oregon State University. Beginning in the 1960s, his research involved computer simulation of aquatic ecosystems. His research then shifted to complex human systems and how organizational systems distort information.

Bill McMillan initiated volunteer snorkel surveys at Wind River to monitor wild steelhead in 1983 and conducted surveys for Wild Fish Conservancy. He wrote *Dry Line Steelhead*, and with his biologist son John, *May the Rivers Never Sleep*, a reminder of Roderick Haig-Brown's early salmon conservation efforts.

Jack Stanford is Emeritus Professor of Ecology at the Flathead Lake Biological Station of the University of Montana. During his 47-year career, he has published over 230 juried papers and books on ground and surface water exchange as a key driver of riverine biodiversity and on the life history diversity and productivity of salmon. In 2011, he received the Lifetime Achievement Award from the International Society for River Science.

David Montgomery is a professor of geomorphology at the University of Washington. He has studied natural and anthropogenic processes that influence salmon and their habitats in the Pacific Northwest and the historical management of salmon in other regions. He is author of several popular science books including *King of Fish: The Thousand-Year Run of Salmon,* and most recently, *Growing A Revolution: Bringing Our Soil Back to Life*.

Kurt Beardslee is a co-founder of the Wild Fish Conservancy and has been the organization's Executive Director for the past 27 years. Kurt manages a professional staff of 19 individuals with a wide variety of technical and scientific disciplines. He has worked on a variety of West Coast wild fish issues, from California to Alaska.

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