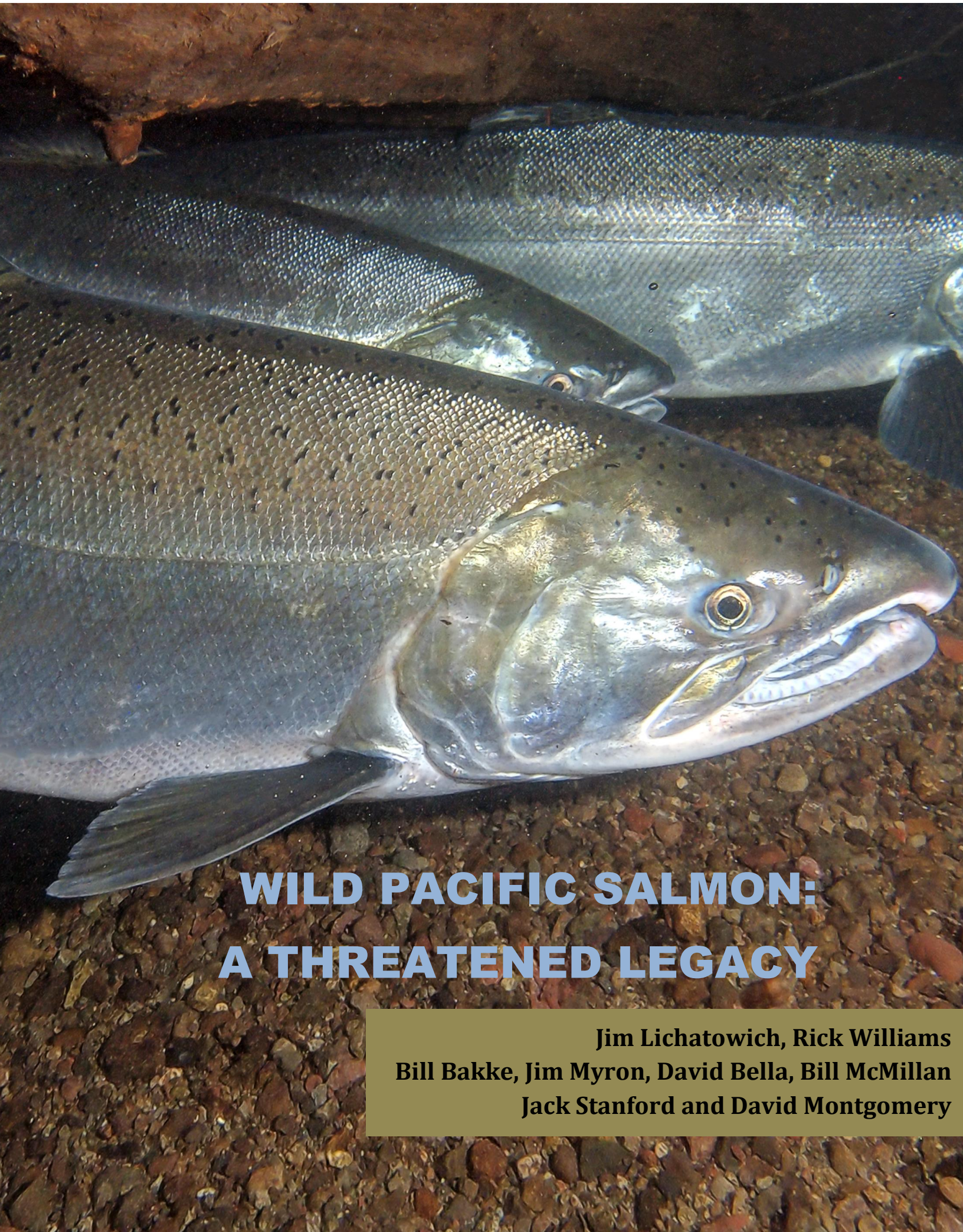

WILD PACIFIC SALMON: A THREATENED LEGACY

Jim Lichatowich, Rick Williams
Bill Bakke, Jim Myron, David Bella, Bill McMillan
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Wild Pacific Salmon: A Threatened Legacy

Prologue

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 prudent management of the wild salmon to the production of commodities for the benefit of sport and commercial fisheries. This amounts to 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. Large industrial operations often create victims among native fauna. In many different ways, wild salmon are the victims of the large industrial production system of hatcheries.

In this document we describe the wild salmon's problem and a solution.

ILD PACIFIC SALMON: A THREATENED LEGACY

Jim Lichatowich, Rick Williams, Bill Bakke, Jim Myron,
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Introduction

The extirpation of wild Pacific salmon in forty percent of their historical range in the Pacific Northwest[1] 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.[2] 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.[3] Even after it became evident that hatcheries are part of the problem, they were rebranded as salmon conservation tools.

While this paper 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,[4] range lands,[5] water,[6] fisheries,[7] wildlife,[8] and agriculture.[9] 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.[10] 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.[11]

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.[12] 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

[a] One recent exception is the Independent Science Advisory Board's examination of the conceptual foundation for the salmon recovery efforts in the

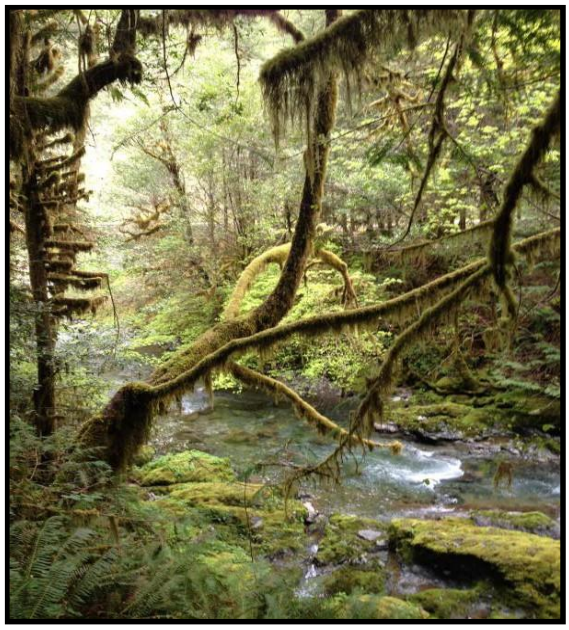
the environmental iceberg hides from easy view the myths, assumptions and beliefs that legitimate the behaviors that create visible issues and they ensure the persistence of ineffective solutions to the salmon's problem. In this report, we call the hidden mass of the environmental iceberg the conceptual 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.[13] 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,* by Prince Charles:

> *"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."*[14]

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



Columbia River. See R. Williams, 2006 at Endnote 78. For a discussion of the conceptual foundation and its influence on salmon management see: D. Bottom, 1997 at Endnote 50; R. Williams, and 12 others, 1999 at Endnote 19; 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.

Salmon Management's Current Conceptual Foundation

A conceptual foundation is the set of principles, assumptions and possibly myths that gives direction to salmon management, research 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.[15] 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.[16]

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.[17]

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.[18] 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."*[19]

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[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. 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."[20]

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.[21] 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."[22] 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.[23]

In spite of the size of the hatchery program in the basin, it has failed to replace wild salmon production lost to habitat degradation.[24] The reliance on technology especially hatcheries is an example of halfway technology which focuses on symptoms instead of the underlying causes.[25] Pope Francis stated it this way: "Merely technical solutions run the risk of addressing symptoms and not the more serious underlying problems."[26] Salmon management's focus becomes the number of

fish produced rather than the ecological processes that determine those numbers.[27] 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.[28]The cause of wild 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.[29]

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.[30]

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."[31]

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.[32] 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 wild salmon legacy passed onto 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.[33] We believe this result

is due, in large part, to the faulty conceptual foundation that guides the development and implementation of the recovery program. It is also a major contributor to the extirpation and impoverishment of wild salmon in the Northwest.

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

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.[34] 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 inappropriate reference points for establishing rehabilitation 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."*[35]

Shifting baselines persist because salmon managers generally have shown little interest in the history of their profession and its record.[36] 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."[37]

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 becomes 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."[38] 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.[39] Using that number as a surrogate for the historical peak or "record" spring Chinook run, it is clear that 470,000 spring Chinook was 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."*[40]

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 their 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 and

satisfy the growing demand from an expanding human population. 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."[41] The loss of faith in nature justifies the reliance on hatcheries and reinforces the flawed conceptual foundation.

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.[42] 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[d] 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.[43] In addition, when it is acceptable practice to supplement natural production with hatchery fish, it weakens the incentive to vigorously protect habitat.

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.[44] Harvest no longer occurred on local stocks after they entered their home streams, but on 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.[45] 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.[46] After

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

describing the importance of understanding how salmon populations are adapted to their local habitats, W. F. Thompson described the 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."*[47]

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.

Salmon Management Focuses on the Production of Commodities

Salmon management agencies have two basic missions: They are charged with ensuring a steady supply of commodities to the sport, commercial, and subsistence fisheries and the economies they support. They are also charged with maintaining the ecological health of wild salmon and their sustaining ecosystems. These two missions can and often do conflict. For more than a century the focus has been and continues to be on economic issues and maintaining the supply of commoditized salmon.[48] The imbalance creates impediments to the effective management of wild salmon.

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.[49] 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.[50] 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, rather than an ecological yardstick.[51] 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

Those statistics describe the performance of the agency's commodity production, but say little or nothing of the ecological state of the salmon-sustaining ecosystems.[52] 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 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—portfolios).
- 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 recommended additional performance measures focus on the ecological processes that sustain wild salmon.

Two basic approaches to salmon management can be characterized as either coarse grained or fine grained. The coarse-grained approach is strongly associated with the current conceptual foundation. We characterized that approach as a focus on the production of commoditized salmon in an industrialized system of hatcheries. The natural production system is simplified and coarsened by largely ignoring the intimate ecological relationships between wild salmon and the ecosystem. Coarse-grained management that gives priority to the industrial production and utilization of salmon is not compatible with the stewardship of wild salmon. The impoverished state of wild salmon gives testimony to that statement. Advances in our understanding of wild salmon biodiversity and ecology and how they relate to the physical and climatic diversity of habitats call for a fine-grained approach that recognizes the complexity of the wild salmon's interaction with their sustaining ecosystems. The fine-grained approach requires more information, more monitoring and continuous institutional and individual learning. The coarse-grained approach with its simplified production system is easier to implement. It can conveniently state benefits in economic 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."[53]

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[54] 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 looking more like what one sees when looking into a kaleidoscope.[55]

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. Management agencies can operate hatcheries and regulate harvest without crossing the bureaucratic boundary of another agency. The nexus of those two activities defines the agency's comfort zone, which is why, in spite of repeated warnings of its damaging effect on wild salmon, there has been no serious attempt to change the fragmented management of ecosystems.[56]

Science tells us that we should be taking an ecosystem approach to the management and recovery of Pacific salmon,[57] but such an approach is not compatible with the current fragmented management of ecosystems. There have been attempts to overcome this impediment, but the bureaucratic boundaries and 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. In fact, embedded in that hidden mass are the assumptions about nature that legitimate the behavior that condones or even encourages the actions that create the visible issues.[58] 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.

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."[59] 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.[60] 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…."*[61]

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[62] have given us an alternative conceptual foundation that addresses those ecological concerns. 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, applicable broadly 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."[63] In discharging this trust responsibility, the public and government trustees must let future generations see the natural world as it was and not as the aftermath 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."*[64]

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. 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,[65] 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. In Table 1, we identified management practices derived from the current conceptual foundations as coarse grained and practices derived from the proposed ecological conceptual foundation as fine grained.[66]

The chasm 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 designed to evaluate 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 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, the District of Oregon invalidated the most recent BiOp on May 16 2016.[67]

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 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 are interconnected**

Implementing the Solution to the Wild Salmon's Problem

What we have presented so far may make the solution to the wild salmon's problem appear to be a simple, straightforward task. Adopt the alternative conceptual foundation; bring management programs into agreement with public trust responsibilities and with current science; and the problem is solved. 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. The current conceptual foundation defines the agency's comfort zone. It coevolved with the fragmented management of ecosystems and is maintained by a shifting baseline. Salmon management programs based on the current, coarse-grained conceptual foundation are less expensive than those that would result from adopting the fine-grained approach.[68]

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

These activities and the behaviors that normalize them will also be 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."

Even if the ecological conceptual foundation were adopted, the irreversibility principle suggests the future of wild salmon, and all aspects of the environment are bleak.[69] 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."[70] 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 the 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."[71]

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 a bold new initiative. We propose that one of the initial steps to bring about a paradigm shift in salmon management is the creation of a wild 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.
- 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.[72] 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."*[73]

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

The many attempts to create salmon refuges or sanctuaries in the last century failed; however, federal waterfowl managers were rapidly creating a system of refuges for migratory waterfowl.[74] Salmon managers chose to rely on hatcheries and ignore the benefits of a system of salmon refuges. That 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 protections provided along city greenways. What matters is the effort to integrate appropriate protections over the range of rivers and streams that salmon depend upon.

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.

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 caused by a switch from the current conceptual foundation to the alternative. 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 a mixed-stock fishery.[75] It's difficult to regulate the harvest of individual stocks in a mixed-stock fishery. So achieving adequate escapements for all the 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.[76] 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-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 …."*[77]

The purpose of hatcheries is to supply commoditized salmon to the sport and commercial fisheries. 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 mixed stock 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[78] and concern regarding the principles that underlay and govern hatchery programs.[79] These concerns led to several reviews and evaluations of hatchery programs by independent scientific panels.[80] 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 that those recommendations exist. A change in burden of proof 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. This approach was superimposed on natural production systems causing them to degrade. 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.[81] The result has been a failure in the current management system.[82]

> **Salmon management must adopt a finer-grained approach to salmon production, one that recognizes the individual population in its natal watershed as the basic management unit. This has been referred to as river-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 has 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 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.[83]

"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."

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.

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 solutions to the wild salmon's problem have proven elusive because managers recycle past solutions that have questionable performance records. The current conceptual foundation encourages a reliance on technology to circumvent or replace ecological processes, which has led to the reliance on hatcheries. Periodically, salmon managers reinvent the role of hatcheries by changing the terminology used to describe their mission. As you read this, keep in mind that prior to the 1950s the massive harvests of salmon were composed largely of wild fish.[84]

In the late nineteenth century, salmon managers had an abiding faith in technology, which led to the belief that the new technology of fish culture could increase salmon abundance beyond natural limits.[85] They believed such an increase could be accomplished if humans controlled salmon reproduction.[86] Hatcheries failed to achieve the goal of super abundance; and, the number of salmon began to decline because of excessive harvest and habitat degradation. By the 1920s the goal of hatcheries shifted. Now fish hatcheries were going to stop the decline and maintain the supply of salmon. The earlier failure was forgotten because managers believed that success was within reach due to new hatchery practices.[87] Juvenile salmon were held in the hatchery for longer periods and released at a larger size. The first experimental steps using this technique appeared successful although no real evaluation was conducted.

Salmon continued to decline. In the 1930s and 1940s, they faced the added threat of main stem dams. Without clear evidence that hatcheries had achieved their previous goals, managers let their faith in technology override lingering uncertainties about hatchery performance. Now the hatchery mission was to mitigate the negative effects of dams and development. Through the 1940s, 50s and 60s mitigation was synonymous with hatcheries. The current conceptual foundation's reliance on technology kept recycling the hatchery solution to the salmon's deepening problems.

However, there was enough concern over the ability of hatcheries to compensate for the effects of the dams that in 1938 the Secretary

of the 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."[88]

In 1999, 60 years after the Board of Consultants tagged the mitigation plan as an experiment, a growing 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."[89]

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 experiment was actually carried out. 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.

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 recycled the same old hatchery solution. This time hatcheries were given missions like supplementation, conservation, or captive brood.[90] And, so here we are in the twenty-first century chained to a tool that has a record of failure, but has an uncanny ability to adapt and reinvent itself for every situation.[e]

This brief history of the use of hatcheries shows how a faulty conceptual foundation can lead to a recycling of the same failed solutions to the wild salmon's problem.

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."[91] 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

[e] 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 had lain 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.

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 as a whole should be implemented.[92] 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.[93]

Although the plan is not being implemented within an ecosystem context as originally intended, 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.

Salmon Management's Focus on Commodity Production

In 1985 and 1986 one coho salmon was counted crossing Lower Granite Dam in the Snake River. In 1987 none returned. The coho run into the Snake River tributaries had blinked out of existence.[94] This is an example of the consequences of mixed stock salmon fisheries described in the quote by W. F. Thompson on page 9. 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 overlooked industrial giant."[95] 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."*[96]

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 fisheries on mixed hatchery and wild stocks overharvested wild fish. Dams and other

habitat degradation imposed another significant source of morality 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 Evolutionarily Significant Units (ESU) 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.

In the Columbia River system, Snake River sockeye were listed under the federal ESA as endangered in 1991. This was followed within the decade, by the listing of 11 additional ESUs of Columbia River salmon and steelhead, and two resident species, bull trout and Kootenai River white sturgeon.[97] An ESU may contain several populations. The listed salmon and steelhead ESUs in the Columbia River actually contain 190 populations.[98] 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.[99]

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.[100] 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.[101]

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.[102]

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.[f]

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 as reported on page 15 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."*[103]

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

[f] A BiOp usually also includes conservation recommendations 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.

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.[104]

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,[105] 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.[106] 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.[107]

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.[108] 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.[109] 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.[110]

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.[111] 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 counted at Bonneville (Figure 1). 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 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.[112]

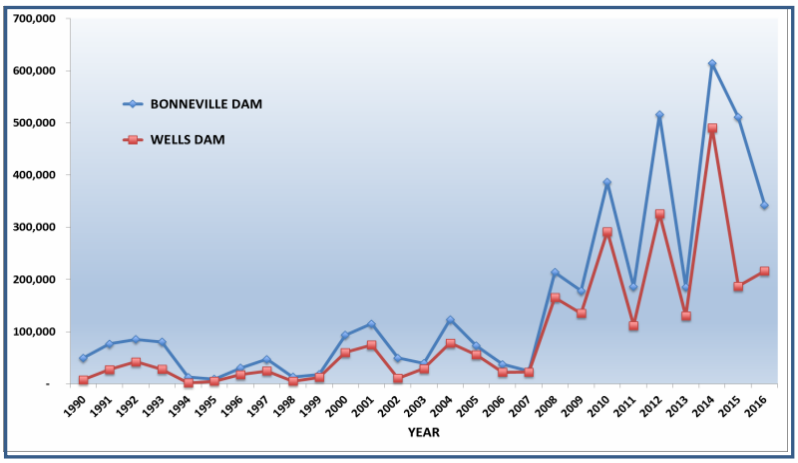

Figure 1. Abundance of adult sockeye salmon entering the Columbia River (blue line) and the abundance of sockeye headed for Okanagan/Osoyoos Lake (red line), 1990-2016.[113]

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 cutoff 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 general 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. Here is an example of the problem we face. This took place just a few weeks ago. In the current session of the Oregon Legislature, there was an attempt to strengthen the State's Wildlife Policy and make it more responsive to the conservation 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.[g] This clearly indicates to us that the Oregon Department of Fish and Wildlife gives commodity production a higher priority than conservation as we described in this report. It also exposes the fallacy that utilization is not, in the end, tied to and dependent on conservation. Clearly the department staffer is working within the constraints of the current conceptual foundation.

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.[114] 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:

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

Because they are part of the Northwest's history and heritage—36%

As a gage 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 Oregon Department of Fish and Wildlife, with its 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.

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.

Bill Bakke is the Conservation Director for The Conservation Angler.

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 its wild steelhead in 1983 and conducted surveys for Wild Fish Conservancy. He wrote *Dry Line Steelhead*, and with 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*.

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