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Faith in Nature:

The Missing Element in Salmon Management and Mitigation Programs

by Jim Lichatowich and Richard N. Williams

— Alder Fork Consulting and The College of Idaho —

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Both authors have *served on numerous salmon management technical panels.*

The 1990s were a calamitous period for salmon and steelhead management. The century-long decline in abundance reached alarming levels leading to the listings of twenty-eight Evolutionarily Significant Units (ESU)[1] under the federal Endangered Species Act (ESA). Many of us working on salmon management and recovery in the Pacific Northwest during the 90s believed that the ESA listings would shake the foundation of salmon management enough to change the status quo. We were wrong. ESA rules intended to improve the salmon's status were bureaucratized, ritualized and normalized to the point that they became part of the status quo, resulting in little real change. Case in Point: the Biological Opinion (BiOp) for the Columbia River Federal Power system, the preparation of which was imposed by the ESA, has been rejected by the courts four times and the most recent one may be on the way to a fifth rejection. The recovery prescriptions in the BiOps have been too close to the status quo for the courts to take the proposed solutions seriously.

The status of salmon remains a crisis. There is no other way to view the listings under ESA. Unfortunately, however, it is a crisis that has failed to cause introspection and critique by salmon managers of the record leading up to the listings. This failure is, in part, due to impediments to the incorporation of current science into salmon management and mitigation programs (Lichatowich and Williams 2009), a general lack of historical perspective among salmon managers (Pauly 1995), and to a pathology resulting from a command and control approach to salmon management (Holling and

> *The salmon crisis has failed to cause introspection and critique by salmon managers of what led to the ESA listings.*

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FROM THE PERCH — EDITOR'S MESSAGE

Believing in Nature's Bounty

by Jim Yuskavitch

Every wild fish advocate is well aware of how historically abundant salmon and steelhead once were. They crowded the rivers during spawning runs and easily supported sustainable fisheries for Native American tribes along with commercial fishermen and sport anglers. And as every wild fish advocate also knows, that incredible abundance is largely gone and river systems that once produced many thousands of fish may now produce just hundreds, or dozens, and in too many cases, none at all.

But that is not because Nature is no longer capable of producing abundance, as Jim Lichatowich and Rick Williams observe in their important cover story in this issue of *The Osprey*. It is because many salmon managers have rejected the idea that Nature can supply enough fish on its own to support prosperous fisheries, may be unaware of how many fish the rivers they manage once produced and rely almost solely on the technical fix of hatcheries. To make matters worse, that view and philosophy tends to be passed down through generations of salmon managers.

What is to be done? It won't be easy to convince salmon managers that they continue to rely on a flawed conceptual foundation, and hatcheries in particular. But there are examples out there, such as Osoyoos Lake sockeye recovery, that don't rely on traditional models that should stimulate a rethink of how we can again return natural abundance to our salmon and steelhead streams.

THE OSPREY

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CHAIR'S CORNER

Kindred Spirits

by Norm Ploss

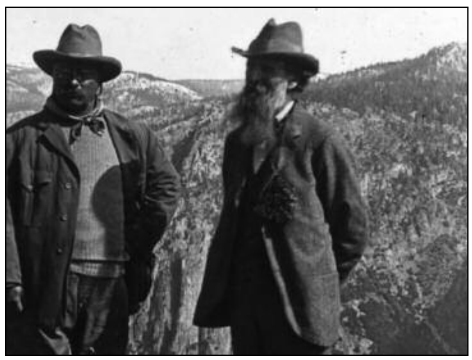
— *Chair, Steelhead Committee* —

Before and since my hip replacement I've had plenty of time to follow a broad spectrum of news. This comes to me naturally by training and personal interest. Some of that news relates directly to fisheries and some relates importantly but tangentially. Good news is out there somewhere, but negative news is easy to find:

• New twist to the Chambers Creek [Washington] Steelhead story. NMFS is moving from a Draft EIS (years in progress) backwards to a Draft EA. Fish conservation advocates argue that only through the process of completing a full EIS can NOAA adequately evaluate the cumulative effects of all Puget Sound hatchery programs on threatened and endangered species including Puget Sound's wild steelhead.

• Steelhead Summit Alliance re: Skagit River. April 18th meeting at the University of Washington. The Skagit, once home to returns of 100,000 wild steelhead and a favorite destination for many anglers, has been reduced to less than four percent of its historical abundance, as described by biologist Nick Gayeski of the Wild Fish Conservancy. Yet according to Gayeski, the river has lost only a third of its productive habitat since the early 19th century. "Prospects and potential for recovery are not as grim as you might think," he said. Many speakers hoped that with a settlement-mandated cessation of hatchery plants into the Skagit River for the next 12 years, the river's wild fish might have a chance at unhindered recovery. Enough, so that the reopening of a sustainable winter catch-and-release angling season may happen.

• An opinion piece in the San Francisco Chronicle on April 20th. Don't ignore San Francisco Bays Needs during the Drought. "Gov. Jerry Brown's decision to require 25 percent mandatory urban conservation while ignoring agriculture — which consumes 80 percent of developed water supply — has been widely criticized. But most people barely are aware that the heaviest burden to conserve water is on our beloved San Francisco Bay estuary — and as a result the Bay may experience a wave of species extinctions in the coming months and years."



President Theodore Roosevelt and naturalist John Muir at Yosemite Valley, California in 1903.

• An article by a pair of authors from Oregon State University published in San Francisco Estuary & Watershed Science [13(1)]. *Forecasting the Most Likely Status of Wild Salmon in the California Central Valley in 2100*. "Since the mid-1800s the Sacramento–San Joaquin river system in the California Central Valley has experienced a dramatic decline in the distribution and abundance of wild salmon, along with many extirpations. The causes of the decline are many, and have been well studied. Despite restoration efforts spanning decades and involving large expenditures, runs of wild salmon in the Central Valley continue to decline. Using the most probable policy and ecological scenarios (i.e. effects of continued harvest, continued stocking from hatcheries, changing climate, continued human population growth and associated demands for scarce water resources) and based on expert judgment", the authors "assessed the most likely future of wild salmon runs in the Central Valley in 2100." They "posed seven open-ended questions to senior salmon science and policy experts in federal and state agencies; local, regional, and national organizations; non-governmental organizations; and universities. With a promise of complete and permanent anonymity, these experts provided answers. Most experts concluded that by 2100 wild salmon in the Central Valley will be extirpated or minimally abundant if current trends continue."

• A bill has been introduced in the House of Representatives that would amend the Magnuson-Stevens Act in detrimental ways. The act governs marine fisheries management in the United States. Representative Don Young (R-Alaska) introduced H.R. 1335, the misleadingly named "Strengthening Fishing Communities and Increasing Flexibility in Fisheries Management Act," which would reverse years of progress made in US fisheries management.

• Lastly as I get to the point of this column, the articles in this current issue of *The Osprey*, without subtlety, highlight the perilous conditions wild salmon and steelhead today as we face the future.

Often enough, I encounter environmental situations or groups working on an issue that looks insurmountable. Almost every time, I recall a (c.1980s) visit to the Gray Lodge Wildlife Area in California's Sacramento Valley. Gray Lodge is primarily a waterfowl refuge and seasonal hunting area and also contained formerly abundant populations of wild pheasants. At the Check Station, I picked up a standalone reprint of an article from the Sierra

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Meffe 1996). These shortcomings have left managers ill prepared to deal with the crisis and have actually caused a retreat into the status quo and the policies that are responsible for the salmon's impoverishment. In this essay, we explore this conundrum through an examination of the nexus of a flawed conceptual foundation and the problem of shifting baselines. Our focus is on the Columbia River where, for thirty-two years, a massive fish and wildlife mitigation program has been underway. The authors have a combined 29 years of service on independent science panels working in association with that mitigation program.

Background

In 1980, the U. S. Congress passed the Pacific Northwest Electric Power Planning and Conservation Act (Power Act), which did three things of significance for the Columbia Basin's salmon. It created the Northwest Power and Conservation Council (Council), a quasi-governmental entity composed of two members from Montana, Idaho, Washington, and Oregon and directed it to work toward greater parity between salmon conservation and hydroelectric power production. The Power Act also directed the Council to develop a fish and wildlife program (FWP) to mitigate fish and wildlife losses due to the operation of the basin's hydroelectric system (Willis et al. 2006). The first FWP was released in 1982 and it has gone through a series of revisions since then. The FWP has been called the world's largest ecosystem restoration program (Lee 1993).

The Council estimated the size of the predevelopment annual run of salmon in the Columbia River at ten to fifteen million fish. Then it set a modest mitigation goal of five million salmon (Williams et al. 2006) amounting to a doubling of the average run size of two and a half million fish in the early 1980s. In the thirty-two years since release of the first FWP and after a total expenditure of about fifteen billion dollars, adult salmon production has not reached the goal of five million fish. Even with the large runs of fall Chinook and sockeye salmon in recent years the total run has remained below the Council's modest goal.

Since 1989, the Council's mitigation program included independent scientific review and evaluation. The review panel created in 1989 has had a succession of three names: Scientific Review Group (SRG) 1989 – 1994, the Independent Scientific Group (ISG) 1994 – 1995 and the Independent Scientific Advisory Board (ISAB) 1995 to the present. While the group's name changed several times, up until about 2000, its membership and its assignment to provide scientific evaluation of the Council's FWP was largely unchanged. In 1996, the Power Act was amended to create the Independent Scientific Review Panel (ISRP), which was given the task of providing annual peer review of individual projects proposed for funding within the framework of the FWP. The ISAB and the ISRP are still performing scientific evaluation of the FWP and the individual projects associated with it.

Fisheries managers have at best a weak understanding of the history of their profession and the former magnitude of pristine abundance.

The FWP's Conceptual Foundation

In 1995, the Council asked the Independent Science Group (ISG) to review the conceptual foundation underlying salmon mitigation efforts in the basin — a project that the ISG had independently started a couple years earlier, but was not able to give it the attention it deserved.

What is a conceptual foundation as the ISG understood and defined it? It is the set of principles, assumptions, and possibly myths that give direction to management and research activities. The conceptual foundation determines how problems are defined and the range of appropriate solutions. It is a powerful part of any management or mitigation program; yet it is rarely acknowledged or critically evaluated (Lichatowich et.al. 2006). The Council and the ISG rightly believed an examination of the conceptual foundation of the FWP was warranted.

The ISG completed its work on the FWP's conceptual foundation in 1996 and published a summary of its report to the Council in *Fisheries Magazine* (Williams et al. 1999). We quote from Williams et al. (1999): "We conclude that management of the Columbia River and its salmonid populations has been based on the belief that natural ecological processes comprising a healthy salmonid ecosystem can, to a large degree, be replaced, circumvented, simplified, and controlled by humans while production is maintained or even enhanced." The ISG then identified three global assumptions that form the FWP's conceptual foundation.

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."
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."
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 (Williams et al. 1999)."

The ISG then concluded: "After reviewing the science behind salmon restoration and the persistent trends of declining abundance of Columbia River salmon, we concluded that the FWP's implied conceptual foundation did not reflect the latest scientific understanding of ecosystem science of

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salmonid restoration" (Williams et al. 1999).

The three assumptions describe a highly simplified salmon production system and the extensive use of technology. Natural resource managers often simplify the resource they are overseeing to the commodity that can be derived from it such as number of fish harvested, logs, amount of water diverted for irrigation, and so on. In the simplified system, the commodity's abundance is the primary measure of management's performance. This reduces the amount and complexity of information needed to "manage" and at the same time gives the illusion of control and predictability over the production of commodities (Holling and Meffe 1996; Bottom 1997; Scott 1998). In salmon management, the sense of control is enhanced by the ease with which salmon can be artificially propagated in hatcheries.

The Council, recognizing inadequacies in its early versions of the FWP (NPPC 1994), released a revised plan in 1994 that included ecological elements consistent with current science as well as elements consistent with the conceptual foundation described above. The Council coordinates the development of the recovery plans, but it can only recommend, not dictate, which parts of the plan are implemented. Salmon mangers actually determine implementation of the FWP through their selection of projects and the proposals they submit for funding. The managers chose to implement those parts of the 1994 plan that were consistent with the familiar, but flawed conceptual foundation. Consequently their selection of projects focused primarily on artificial propagation and fish passage. They largely ignored those parts of the plan based on current ecological science including protecting biodiversity and creating native salmon and steelhead refuge watersheds. In its review of the suite of projects actually implemented, the ISRP noted that, "There is a noticeable discrepancy between the mix of projects actually funded and the ISRP's interpretation of the intent and priorities of the [1994] FWP" (ISRP 1997). By their selection of projects, managers clearly showed the power of conceptual foundations, even one with serious flaws, to influence decisions.

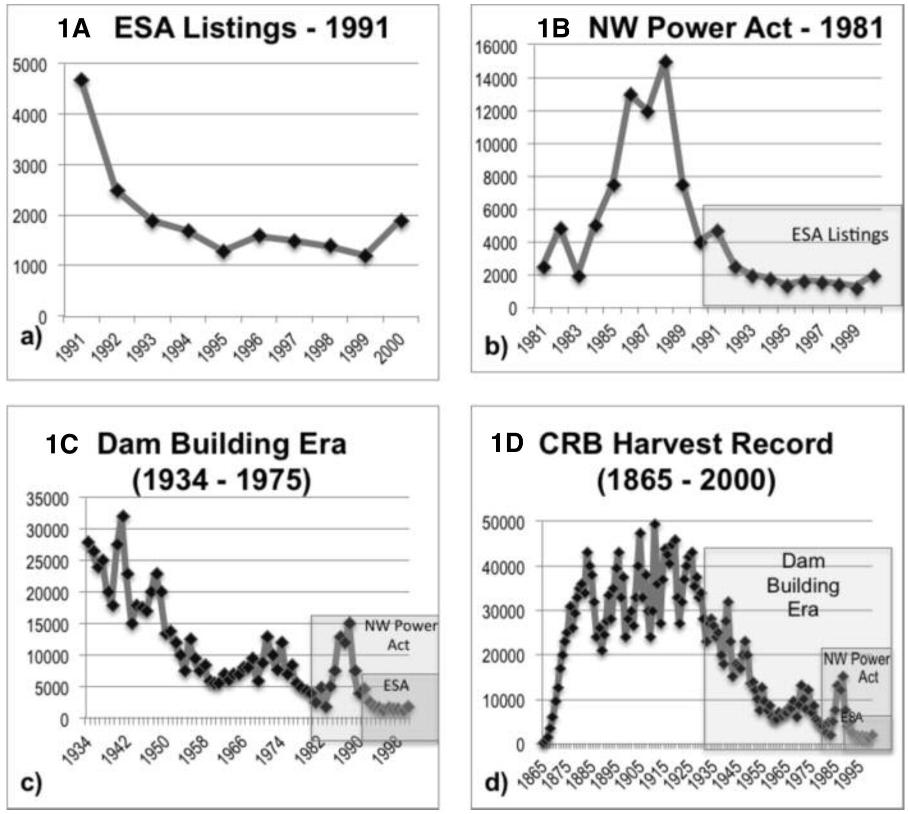

Figure 1. Shifting Baselines shown by Columbia River salmon and steelhead harvest of four different time periods (a-d) starting with 1991 ESA Listings. Note shaded boxes incorporate the previous graph into the next longer time series. Years of harvest are shown with harvest in pounds (x 1000) on the Y axis in each graph.

Why would managers implementing a salmon mitigation program that expends well over a hundred million dollars annually cling to a flawed conceptual foundation? We believe an important part of the answer lies in the concept of shifting baselines — and their consequences!

Shifting Baselines

Fisheries managers have at best a weak understanding of the history of their profession (Smith 1994). They are also largely unaware of the magnitude of the difference between the pristine abundance of important fish stocks and their current status. In recent years, several authors have tried to correct this deficiency, but its persistence has created and maintained the shifting baseline syndrome (Pauly 1995; Roberts 2007; Jackson et al. 2011; Bolster 2012).

Here is a brief description of the syndrome. As each generation of fisheries biologists enters the profession, it considers the status of fish stocks at that time as the baseline, the standard against which progress or lack of it is to be measured. In the case of a declining fishery, this leads to a gradual downward shift in the baseline as each generation of young biologists enters the profession and ultimately to the impoverishment of the fishery, as can be seen in Columbia River Harvest data from 1865-2000 (Figure 1). The insidious feature of this process is that the warning signs on the way to impoverishment largely go unnoticed (Roberts 2007).

Harvest trends in Columbia River salmon (Figure 1a and 1b) in recent years show the low abundance of populations through the 1990s with rebuilding starting in 1999. Examining harvest trends over a longer time series (Figure 1c and 1d) helps put the very

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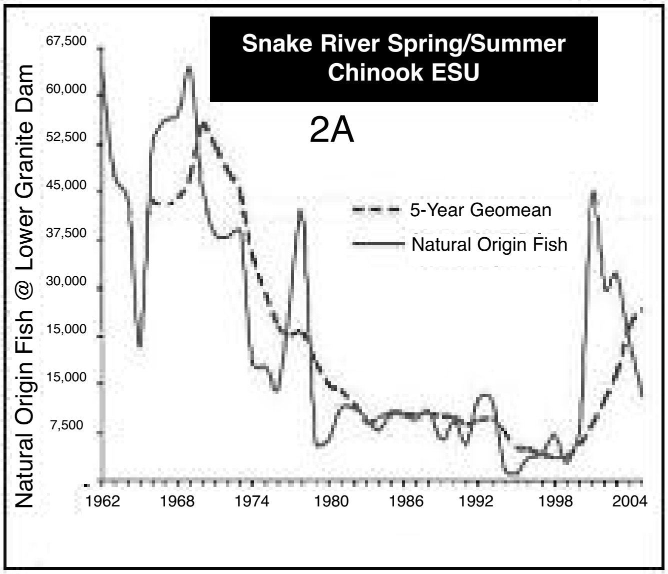

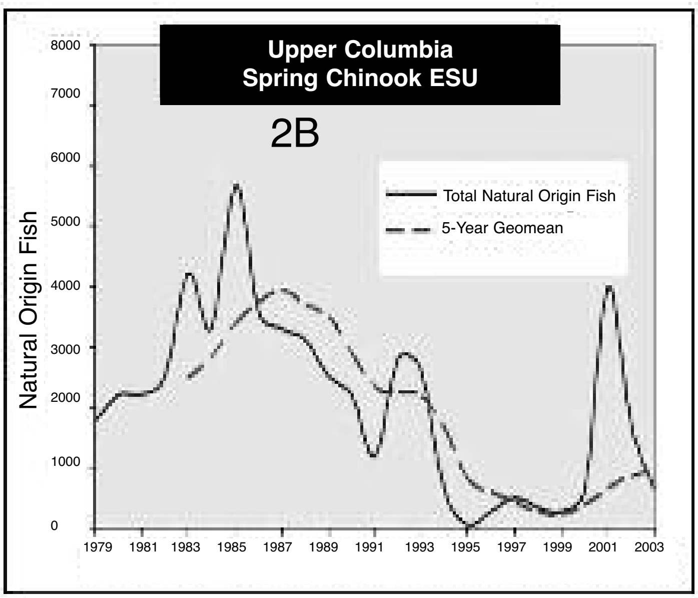

Figure 2. Returns of natural origin (a) Snake River Spring/Summer Chinook, 1962 – 2005, showing a sharp increase and decrease between 1999-2005 and (b) Columbia River Spring Chinook, 1979 – 2003, showing a sharp increase and decrease in 2001.

modest gains achieved in recent years into perspective compared to historical abundance. The longer trendlines also underscore how depressed current populations are compared to historical abundance. Shifting baselines causes us (inadvertently) to overlook historical records and see current modest successes as something more than they actually are.

Shifting baselines cause another problem. Because we don't know the historical productivity of salmon in the smaller ecoregions of Columbia River Basin, we fail to understand and appreciate the latent productivity that can be released when environmental and human caused constraints are reduced or eliminated. We have, however, had snapshots of that capacity in 1991-1993, and 1999-2004, when a combination of high smolt production (mostly hatchery origin), and favorable environmental conditions in the river and ocean resulted in large runs of salmon and steelhead (Figure 2).

Managers have viewed these spikes in abundance as evidence that the artificial production system for salmon is working. A few politicians have gone as far as to declare salmon recovery efforts successful. That interpretation is consistent with the conceptual foundation. Unfortunately, it misses the larger lesson, which is that salmon and steelhead have an innate ability to respond rapidly to favorable ecological conditions. This is even more true of wild fish than for hatchery fish.

If a generation of salmon managers views already impoverished populations of salmon as the baseline against which the performance of their mitigation programs is measured, it can actually lead to practices that attempt to maintain those populations in their impoverished state (Roberts 2007). The shifting baseline syndrome clearly hides the magnitude of the decline in a fishery by ignoring longer-term historical records and consequently, the magnitude of management's failure. A shifted baseline allows the periodic occurrence of "record runs" that are actually a small fraction of the real, historical baseline (Lichatowich 2013). Since the magnitude of management's failure is hidden, there is little incentive for critical review or change in the status quo. Failed management practices are continued as in the example of the Council's 1994 plan described above.

The nexus between a shifting baseline and a flawed conceptual foundation has another important consequence. If the managers falsely believe that the impoverished state of the salmon when they entered the profession is the baseline, it will cause them to conclude that natural production cannot be expected to make a significant contribution to the existing fisheries and satisfy the growing demand from an expanding population. We have, while serving on independent scientific review panels, 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." It is an attitude that helps ensure that a flawed conceptual foundation and its failed mitigation practices will persist. It's a self-reinforcing strategy. The loss of faith in nature justifies the reliance on hatcheries to boost the number of salmon. The weight of evidence now supports the conclusion that those hatcheries are contributing to diminished productivity of natural production, which reinforces the lack of faith in natural production (Chilcote et al. 2011; Christie et al. 2011; Araki et al.2007a; Araki et al. 2007b; Kostow and Zhou 2006).

Discussion

We discuss two examples of recent

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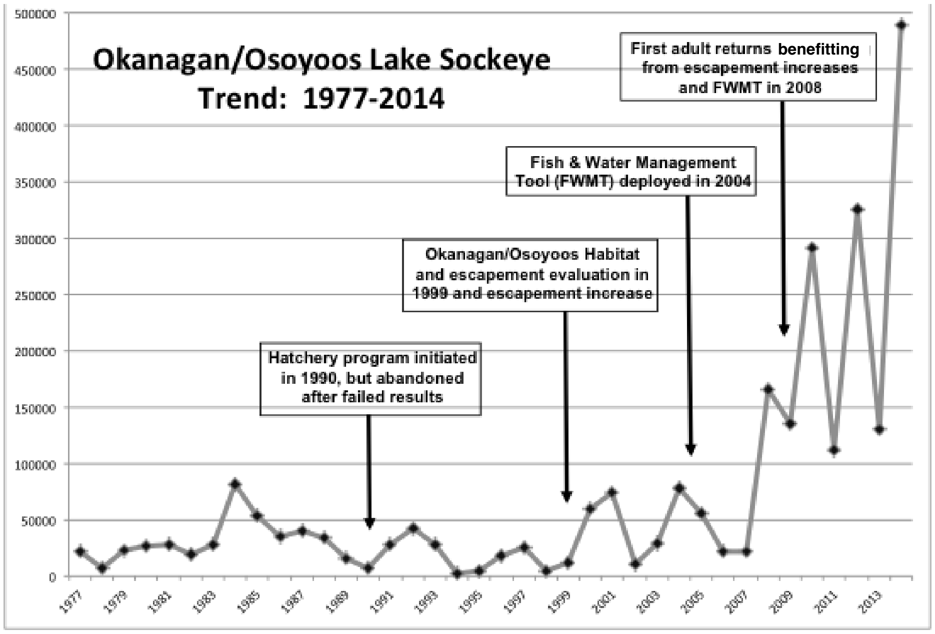

Figure 3. Abundance of Okanagan/Osoyoos Lake Sockeye, 1977-2014, showing the dramatic increase in recent years. Figure courtesy Bill McMillan

salmon recovery programs. One illustrates a strong faith in nature and shows why its loss is not justified. The other illustrates that the loss of faith in nature can lead to bizarre decisions.

Okanagan River/Osoyoos Lake Sockeye

The Columbia River sockeye salmon followed the general trend in declining abundance of the other salmon species in the basin. The commercial fishery for sockeye was terminated in 1972. The average run over the 35 years following the closure of the fishery was about 72 thousand fish. In 2008, the Okanagan River/Osoyoos Lake sockeye (Osoyoos) underwent a dramatic increase in abundance with 213, 607 fish crossing Bonneville Dam. This higher level of productivity has continued through 2014 with 614, 179 sockeye counted at Bonneville (Figure 3). The Osoyoos sockeye made up about 80 percent of the counts of sockeye salmon over Bonneville dam and most of the Osoyoos sockeye crossing Bonneville Dam are wild. Hatchery production makes up about 10 percent of that run. Keep in mind that the Osoyoos sockeye spawn above nine dams in the Columbia River.

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, but they couldn't have been the main cause, because if they were, it would have led to dramatic increases in other salmon populations. Instead, it appears the main causative factor was a "non-traditional mitigation measure" (Kahler 2013). The success started with studies of the Osoyoos sockeye's life history and the identification of ecological factors that limit survival during the part of their life cycle spent above Wells Dam. In 1999, following a review of the capacity of spawning habitat, the sockeye escapement target was increased from 38, 900 to 58, 730 spawners with provision to increase to 135, 471 (McMillian 2013). This in itself showed a considerable faith in nature. 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. The FWMT was also used by managers to help reduce oxygen depletion and temperature constraints on juvenile rearing habitat. Once the FWMT was implemented in water year 2005, smolt production jumped from an average three hundred thousand a year to three million with a high of over eight million (Kahler 2013).

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 his-

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River	Number of Dams	Number of Anadromous Salmon	Habitat	Restoration Focus
Osoyoos	9	1	Major restoration effort though FWMT	Natural production
Elwha	0	8 (5 sp Pacific salmon, steelhead, coastal cutthroat and bull trout	Pristine habitat above old dam sites	Major hatchery program superimposed on recovering natural production

Table 1. A comparison of the Osoyoos and Elwha salmon restoration programs.

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tory 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. It also required a strong faith in nature (and the sockeye salmon!) to go against conventional wisdom and invest in an ecological approach above nine dams.

The Elwha River Ecosystem Restoration Program

The removal of two large dams on the Elwha River in 2012-2014 has received national attention. Those dams blocked salmon migration to the upper basin since early in the 20th century. Removal of the dams gives salmon access to pristine habitat inside the Olympic National Park. The circumstances in the Osoyoos and the Elwha restoration programs could not be more different (Table 1).

The removal of the Elwha dams giving salmon access to pristine habitat seems to establish a set of circumstances that would not require a strong faith in nature to emphasize the recovery of natural production. However, the recovery plan contains this statement "This section introduces the use of artificial propagation for certain stocks as a **primary** (emphasis added) and effective means to meet plan preservation and restoration objectives. (Ward 2008)"[2] As a result, the recovery plan emphasizes the use of artificial propagation. We believe this emphasis is unwarranted and unneeded for the recovery of natural production in the basin. Furthermore, the superimposition of a large hatchery program will likely hinder the restoration of natural production among the Elwha's diverse salmonid stocks.

Part of the recovery program includes a new sixteen million dollar hatchery. Part of its purpose is to provide a refuge for native salmon during the expected high levels of sediment during dam removal operations; however, there is little doubt that the hatchery will remain at full capacity after the sediment levels drop to a normal range. In its review of the Elwha restoration program the Hatchery Scientific Review Group (HSRG) stated: "The main concern the HSRG has with the Elwha Plan is the potential unintended negative consequences of excessive and prolonged hatchery influence (HSRG 2012)."

The author Dylan Tomine summed up the situation on the Elwha at a public meeting on the Recovery Program. He said "We have lost faith in Mother Nature."[3] We agree!

Removal of the Elwha Dam offered a prime opportunity to let nature restore the Elwha River's anadromous fish runs instead of the same old hatchery model. Photo courtesy John R. McMillan, NOAA/NWFSC

Faith in Nature

"*And most important, only when governments that typically ensure economic interests and values over all others decide that they are willing to reconstruct the human salmon relationship as an ecological one rather than an economic one will the true salmon wars, the wars between society and the salmon be over.*" (Scarce 2000).

If we go way back to the beginnings of salmon management by Euro-Americans, we would clearly see that the conceptual foundation identified in Williams et al. 1999 and reproduced earlier in this paper has its origins in a few basic assumptions made by those first managers. Salmon managers today will often bristle at the suggestion that their work is predicated on assumptions made 130 years ago. But the assumption that the supply of salmon could be maintained if the natural production system was simplified and controlled has been documented as management's initial conceptual foundation (Lichatowich 1999). Over time, that conceptual foundation has been adjusted to reflect changes brought on by new technology and industrial development in the Columbia Basin. However, the basic assumption that simplifying and controlling production remained the underpinning of salmon management through all the periods of shifting baselines shown in Figure 1 (Lichatowich et al. 1996).

It is our conclusion that shifting baselines and a loss of faith in nature allowed the false assumptions and the resulting flawed conceptual foundation to persist in spite of its record of failure. Successful salmon recovery programs that deviate from the current approaches, such as the Osoyoos, should cause the Council and salmon managers throughout the region to reexamine, once again, the underlying conceptual foundation of the FWP. Perhaps with Osoyoos as an example of success and with a renewed faith in nature, managers may be willing to reconsider the assumptions made so long ago and move beyond their constraints into a more ecological relationship with the salmon.

Citations:

1 ESUs are the salmon equivalent to Distinct Population Segments (DPS) commonly used in ESA listings and recovery planning.

2 Page ix Elwha River Fish Restoration Plan

3 Tomine's statement at the meeting was shown in the documentary film *Dam Nation.*

Steelhead Persistence and Adaptation in a Warming World

By Lisa Crozier and Michelle McClure
— NW Fisheries Science Center, NOAA Fisheries —

Michelle McClure is currently the division director for the Fishery Resource Analysis and Monitoring Division at the NW Fisheries Science Center (NOAA) in Seattle. She spent many years conducting research and working with policy makers on issues related to the recovery and conservation of salmonids in the Columbia River Basin, and co-led the Interior Columbia River Technical Recovery Team for salmon and steelhead. She has been working on issues of climate change related to endangered species, and is beginning to focus on marine species subject to harvest as well.

Lisa Crozier has worked in the Fish Ecology Division at the Northwest Fisheries Science Center since 2004. Her primary research goal since coming to NWFSC is to quantify the effects of climate change on population viability of Pacific salmon, considering both ecological and evolutionary responses over the full life cycle. She works mostly on salmon in the Columbia and Sacramento rivers.

With a geographic range that once extended as far south as Baja, California, the broadest range of life histories and highest thermal tolerance of any Pacific salmon, *Oncorhynchus mykiss* is arguably the most diverse and adaptable of the six Pacific salmon species (*Oncorhynchus spp.*) native to the U.S. As climate change progresses and aquatic environments adjust, the ecological and genetic diversity of steelhead will likely prove decisive in facilitating this species' persistence. Like other salmon, they excel at colonizing newly created habitat and adapting locally to complicated dynamics. However, 11 out of 14 populations of steelhead on the West Coast are already listed as threatened or endangered under the Endangered Species Act, and thus additional stress from climate change poses a more ominous challenge. How will steelhead respond to climate change? Our discussion complements a recent review of ocean stages by Kate Myers and Nate Mantua ("Climate Change and Ocean Ecology of Northwest Steelhead," *The Osprey*, May 2013); we here focus on climate impacts and responses expected in freshwater life stages.

> *Rising temperatures are the greatest risk for fish populations that already experience near-lethal summer temperatures.*

Projected Climate-Induced Changes in Freshwater Habitats

Rising year-round temperatures and shifts in hydrological regimes are the major climatic changes to freshwater that will impact salmon life history and individual fitness in the coming decades. Under a business-as-usual carbon emissions scenario, air temperatures in the Pacific Northwest are expected to rise 2.3-9.2°F in winter and 3.4-9.4°F in summer within the next 50 years. Water temperatures will likely warm at about 80% of the rate of air temperature. Reduced snowpack at higher elevations will also produce an earlier and smaller spring freshet. Changes in precipitation are far less certain, and variability in historical precipitation has always been very high, extending the time horizon further into the future when mean changes due to climate change will be detectable.

Nonetheless, many climate models project more extreme storm events in the cool season, while drier summers become the norm. Increased winter flooding and summer drought may thus pose increasing threats to salmon freshwater stages.

How will these physical changes affect steelhead? Rising temperatures present the greatest direct risk for populations that already experience near-lethal summer temperatures. These include steelhead in warmer streams in California, southern Columbia and Snake Rivers, and western Oregon. High temperatures limit survival of adult migrants, especially those that migrate long before spawning, "summer-run" fish, and juveniles that typically spend one or more summers in freshwater.

More than other salmon, adult steelhead in the Columbia River use cool tributaries as thermal refugia along their migration route. In general, the more time they spend in these refugia, the lower their survival. Seeking headwater tributaries in Idaho, however, is also associated with lower survival. The primary reason thought to explain these observations is that steelhead concentrated in smaller refugia or tributaries become more vulnerable to harvest. Importantly, even catch-and-release fishing causes far higher mortality for salmon in warm conditions, and females are more likely to die after handling than males.

Exposure to high water temperatures and low flow is often punctuated by disease outbreaks, which can lead to dramatic fish kills. In 2002, roughly 70,000 Chinook salmon died in the Klamath Basin when gill rot disease flourished. The warm temperatures

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and low flows caused by the combination of a drought year and human water diversion provided perfect conditions for the disease to spread quickly and reach epidemic status. Warming can increase virulence of a variety of diseases by accelerating population growth rates and movement of disease agents. Disease transmission among fish also increases when fish are tightly concentrated into limited pools. Furthermore, salmon immune systems are compromised by thermal stress. Thus high temperatures and close concentrations of salmon are very strong predictors of high mortality.

Sub-lethal temperatures are just as important as lethal temperatures in shaping population response to climate change. Exposure of adults to sublethal temperatures during migration may impair egg viability, either through reduced egg provisioning or direct thermal stress in utero. Developmental temperatures can affect skeletal and muscle morphology, as well as fin position. However, the influence of temperature on rates of growth and development is perhaps most important of all.

Metabolic rates increase exponentially as temperatures rise, affecting development and energy balance at all life stages. For example, in warmer water, fry emerge earlier and smaller, with smaller yolk reserves. These smaller reserves increase the urgency of switching to an external food supply in early winter or spring. Historically, natural selection has favored emergence timing that matches the availability of food, leading to highly population-specific spawn timing. Changes in thermal regimes will alter both of these processes, potentially resulting in a mismatch between fish needs and prey availability. This in turn will direct pressure on and possibly drive evolution in spawn timing.

Once they reach the juvenile stage, growth rates have an optimum temperature that reflects the trade-off between increased food consumption and the acceleration of metabolic rates at warmer temperatures. At warmer temperatures, food is usually more abundant; however, prey quality can also decline, and fish need more food to sustain minimum functioning. The optimal temperature for growth is therefore higher in very productive environments with few fish and lower in more nutrient-poor environments with higher density. Thus, a web of interactions affects juvenile steelhead physiology.

Winter water temperature also has important ramifications. Food is scarce in winter, placing a priority on minimizing energetic expenses over prey capture. Shorter, warmer winters could bring higher energetic costs and higher mortality. Come spring, juvenile steelhead "determine" whether and when to smolt, based in large part on growth rates and lipid reserves. If juveniles grow quickly enough to lower their mortality risk in the ocean, but not so quickly that conditions in freshwater favor skipping the ocean stage altogether, they will smolt.

Salmon are carried downstream by the spring freshet during their juvenile migration, and lower flows (resulting from reduced snow accumulation over winter) typically lead to lower smolt survival. Migration timing also plays an important role in smolt survival, and will likely advance earlier in the year with warmer, smaller and earlier spring flows. Ocean arrival timing profoundly influences marine survival; however, it is not clear whether changes in ocean conditions will shift the optimal arrival time.

In mid-elevation basins, peak flows might shift from spring to winter, with potential effects on egg survival, growth, and migration timing. More intense storms in fall and winter are likely and would result in floods of greater magnitude and frequency during these seasons. These drivers are expected to negatively influence fall-spawning salmon and trout. However, rainbow trout and steelhead might be better suited for this hydrological regime because they spawn after winter flooding. The effects on adult migration might be population-specific, with access to spawning areas dependent on migration timing that is appropriately matched to adequate flows for passing over physical barriers. In some cases, the current migration timing might be less successful due to the new combination of thermal stress during migration, low flows, and winter flooding. However, these consequences are highly site specific.

In sum, most projections indicate that salmon habitat will decline with climate changes anticipated during the 21st century, although *O. mykiss* suffers less than other salmon because they spawn in the spring. Despite this general pattern of habitat decline across salmon species, growth will likely improve in some cases, such as warming of relatively cool habitat. Similarly, streams with low flows tend to improve with projections of increased fall and winter rain, although these projections are uncertain.

Negative effects of warming often appear in summer and winter, when consumption cannot compensate for increased metabolic demands. Reduced precipitation in summer exacerbates the risks posed by extremely low flows. Changes in growth rate also affect the timing of vulnerability to predators such as bass, which are size selective.

A specific analysis of vulnerability for Pacific Northwest steelhead found that populations in the southern part of the region face greater threats from temperature, while those in the interior and northern parts will likely confront substantial flow changes. Unfortunately, many populations that already face severe conservation challenges also face the greatest threats from climate change.

Anthropogenic Stressors

The direction of these impacts is similar to that of many anthropogenic effects already confronted by salmon populations. Many habitat modifications raise stream temperature, increase the intensity of flooding and reduce summer minimum flows. Loss of shading from riparian vegetation and interchange of flows between the channel and subsurface flows, for example, raise stream temperature. Water that transits through the ground is cooler and more consistent than water exposed directly to radiative heating.

Barriers, armoring, and incised channels all reduce connectivity between streams and their floodplain, limiting the natural ability to maintain diverse stream habitats that would otherwise

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provide refugia from high temperatures and flooding. Irrigation withdrawals exacerbate low flows, leaving some streams completely dry in summer.

Construction of dams and storage reservoirs for flow control and year-round power production has altered both the thermal and hydrological regime of regulated rivers. These effects are similar to climate change effects in some cases, but opposite in others. In the Columbia and Snake Rivers, freshets are much smaller and peak earlier in the year than would occur in a free-flowing river.

Reservoirs typically increase summer temperatures by lengthening the time for equilibration between water and air temperature, and increase transit time for smolts. However, some dams are managed to release water that is cooler in summer and warmer in winter than a free flowing river. Targeted releases of deep, cool water from stratified reservoirs such as Dworshak Reservoir in Idaho can lower temperatures in some reaches. These cases present opportunities for mitigating some effects of climate change.

Adapting to Climate Change: Plasticity and Genetic Change

In response to all of these environmental changes, organisms can alter their exposure or sensitivity to unfavorable conditions by changing behavioral or physiological traits. Phenotypic traits, such as migration timing or thermal tolerance vary in how "plastic" they are. Plastic traits change systematically with environmental conditions within the lifetime of an individual. This relationship is called a "reaction norm." Highly plastic traits that have shifted quickly in response to recent climatic changes include age at juvenile migration, growth rate, size at age, seasonal timing of adult migration and spawning, and fecundity.

Evolutionary adaptation, on the other hand, reflects selection acting on a trait, and occurs over generations. Thermal tolerance, for example, is strongly genetically determined, and will likely require strong selection in order to change. Nonetheless, *O. mykiss* contains genetic variability for this trait, as shown by rapid laboratory selection of rainbow trout with greatly enhanced heat tolerance. Similarly, developmental sensitivity to temperature is generally considered to have low plasticity, although exposure to warm temperatures during particular developmental windows has been shown to alter these responses in some fish. Like heat tolerance, developmental responses in *O. mykiss* have adapted locally to natural habitat heterogeneity using genetic variation that exists in many populations, and hence could theoretically evolve in response to climate change. In fact, many traits

The complexities of climate change make it difficult to predict the rate of genetic response to a changing environment.

involved with juvenile growth and development, age at smolting and age at maturity have successfully adapted in less than 30 generations to new habitat after Chinook salmon were introduced in the southern hemisphere.

Although historically, genetic adaptation to local environments clearly has occurred in nearly all traits, it is difficult to predict rates of response to future climate change because of the complex selection landscape in the wild. Many traits are tied together physiologically or temporally. For example, if you change migration timing, the subsequent life stage may face a total different set of conditions. Our predictive ability is further hampered because it is usually not possible to employ standard methods for demonstrating evolutionary change in response to recent climate change in salmonids, because we cannot directly compare modern and ancestral populations under the same conditions, nor can we usually identify the parentage of all individuals in a population. Nonetheless, some examples of genetic change have been shown in migration timing.

Serendipitously, several decades ago researchers in Auke Bay, Alaska inserted molecular markers into the genome of pink salmon to differentiate between early and late modes of a naturally migrating population. One marker specifically identified the late migrants, while neutral markers tracked levels of genetic drift in the population to separate natural selection from random processes.

Frequencies of these early vs. late migration markers have been independently monitored for both odd- and even-year populations of pink salmon since the 1970s. In both populations, the late-migration mode disappeared in the early 1990s, coincident with some unusually warm years in the stream. Loss of the molecular marker indicated that the entire late-migrant segment of the population had disappeared rather than their descendants having shifted to an earlier migration (a plastic response).

Migration timing, like most traits, incorporates both plastic and genetic components. In the Columbia River basin, steelhead, sockeye, and Chinook salmon have also shifted their migration timing since the 1950s. Most adult sockeye and spring/summer Chinook salmon stocks migrate prior to warm summer temperatures, and they now migrate earlier than in the 1950s. Conversely, many fall Chinook and steelhead stocks migrate after summer temperatures decrease, and they have shifted their migration date later in the year. Both responses allow fish to avoid peak temperatures in the mainstem, which now consistently hover over 20°C for much of the summer.

Later migration appears especially advantageous for steelhead adults because it reduces the bioenergetic cost of holding over the entire winter. This cost increases exponentially with temperature, so a difference of even 1°C in mean temperature entails loss of precious reserves that will not then be available for reproductive activity. In the Columbia River basin, these shifts are likely a plastic response to environmental cues used by individu-

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als to modulate their behavior, at least in part. However, evidence from an analysis of sockeye salmon migration survival suggests that selection may have acted on these populations as well.

Selection has acted by shifting the reaction norm for migration timing over the past 60 years. Steelhead and other salmonids have been well served by a combination of genetic and plastic responses that have allowed them to occupy diverse habitats and conditions. They can respond quickly to changes in the environment, but natural selection refines the response over time. Thus evolution and plasticity act together to shape the behaviors that support anadromy in Pacific salmon and that allow them to respond to a changing world.

However, populations must persist in order to adapt. A primary concern regarding modern climate change is that depressed populations may lack sufficient genetic variation to provide the raw material for rapid evolution. This would mean salmon populations are closer to going extinct in response to strong selection or chance events simply because they have a smaller starting point. Thus, a process that might have eventually produced a better-adapted phenotype could die out before it has time to spread within or among populations. Nonetheless, in natural populations, some traits have already adapted in response to recent climate change.

What Can We Do?

In summary, the major climatic change to the freshwater environment that will impact steelhead in the coming decades is rising temperature. Risk of increased mortality is greatest in summer, but shifts in flow regime may increase winter flows and storm intensities, resulting in decreased snowpack with an earlier spring freshet and lower minimum flows.

Despite the high adaptability and flexibility of steelhead, long histories of salmon abundance from the paleological record and historical documentation reveal large swings in population size over time. Not all of these fluctuations are climate-driven, nor do all populations respond similarly to a given climate. Nonetheless, many of these swings do correlate with major changes in climate, from regime shifts of the Pacific Decadal Oscillation to the Little Ice Age. Generally, warmer climates have been less favorable for salmon, demonstrating limits in the ability to compensate for climate change.

These impacts are similar in direction to many anthropogenic impacts already confronted by salmon. On the plus side, the similarity between anthropogenic and climate change impacts provides an advantage: restoration to mitigate anthropogenic impacts can also lessen many impacts of climate change. Tim Beechie and his colleagues have laid out a clear framework for conducting restoration to mitigate for climate change. Their guidelines for conservation prioritize restoring natural processes that keep waters cool and habitats diverse. Restoration of these processes will require maintenance of natural flow regimes, reconnection of streams with their floodplains, and expansion of riparian vegetation.

Like other salmon, adult steelhead can be most vulnerable when they seek thermal refuge in deep pools or headwater tributaries. Fish hold in these pools and are relatively easy to catch during such periods. Even if released after catch, steelhead and other salmonids experience high rates of mortality after handling. Thus, protection of thermal refugia in general and from fishing in particular is a key component of preserving a successful summer-run life cycle.

Steelhead face many challenges in the coming years as temperatures continue to rise, stream flows change, and humans demand more of limited freshwater. The odds of persistence for this species are enhanced by a natural ability to adapt to variable environments. However, to foster this resilience, we must ensure that populations remain abundant and that heterogeneous habitats remain accessible to the greatest extent possible.

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McKenzie River Chinook Salmon: A Legacy Population in Peril

By Dave Thomas and Arlen Thomason

— McKenzie Flyfishers —

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You can learn more about the McKenzie Flyfishers at: https://mckenzieflyfishers.wordpress.com

The Willamette River originates in the Cascade Mountains and drains most of northwest Oregon, joining the Columbia River near Portland. The tributary rivers of the Upper Willamette River Basin (UWB) have supported a spring run of Chinook salmon (*O.tshawytscha*) since long before humans arrived. The stock is assumed to have evolved its early seasonal run timing in response to the need to pass the Willamette Falls near Oregon City when there was sufficient flow. It has been estimated that in the Nineteenth Century, Chinook escapement in the basin could have numbered 275,000, with approximately 40% returning to spawn in the McKenzie River subbasin. Since then, the wild Chinook population has decreased dramatically, with only two of seven subbasin populations still considered viable. Of those two, the McKenzie River population is by far the strongest, remaining the best hope for recovery of UWB Chinook salmon, and it has been designated a "legacy" or "stronghold" population by fishery managers. That fact notwithstanding, the McKenzie Chinook population has itself shrunk to an alarmingly small size, recently recording an all-time low. The "last best hope" for saving UWB Chinook salmon from complete extinction is in serious danger. How we got to this point and what is being done or could be done to reverse this trend is the subject of the remainder of this article. The usual suspects—habitat, harvest, hatcheries, and hydropower—all play their roles.

The McKenzie River begins high in the extensive lava field aquifer of the central Oregon Cascades and tumbles west for 90 miles through a National Wild and Scenic River corridor to its confluence with the Willamette River near Springfield. The river drains a basin of 1,340 square miles and is fed by several major tributaries, most notably the South Fork, which is 30 miles long and historically provided prime spawning habitat. Like the rest of the basin, the McKenzie subbasin saw substantial anthropogenic environmental (habitat) degradation during the late Nineteenth and early Twentieth centuries. By the late 1940s, an estimated 46,000 spring Chinook returned to the McKenzie River. Part of this reduction was certainly due to habitat degradation and water removal, particularly in the developed lower river. And though there is little or no exact documentation of the ocean and freshwater harvest in the lower Columbia River during the early years, it's known that those rates were often extremely high, requiring strict regulations to avoid extirpation of the entire Columbia River salmon run.

The wild McKenzie River Chinook population is the most genetically intact in the Upper Willamette River basin.

Nevertheless, at that time it was proposed that the McKenzie River could potentially still support up to 80,000 spawning Chinook. However, between 1942 and 1969, a series of dams were constructed in the Willamette Basin, creating barriers to substantial proportions of spawning habitat. Three dams were constructed on the McKenzie River — Blue River Dam, Cougar Dam and Trail Bridge Dam — resulting in the loss of approximately 22% of potential spawning habitat.

Along with the wild population of McKenzie Chinook salmon, the Oregon Department of Fish and Wildlife (ODFW) or its precursors have maintained a hatchery stocking program on the river since 1907. Prior to World War II the Chinook hatchery program followed a practice of blocking the entire salmon run in the lower river to allow the collection of eggs and milt. Today this practice would be considered astounding; however at the time, fishery managers assumed that all fish of one species were essentially interchangeable and could be replaced or reassigned as Man found it convenient. At the same time, hatcheries were considered more efficient at producing fish equivalent to those spawned in nature. Thus it was thought that hatchery spawning was a boon both to the fish and to those who benefited from their harvest. Today we know differently about the true effects of hatcheries, a subject we will come back to below.

From 1945 to 1960 an average of 18,000 returning Chinook on the McKenzie River was observed, with a high of about 46,000. However the con-

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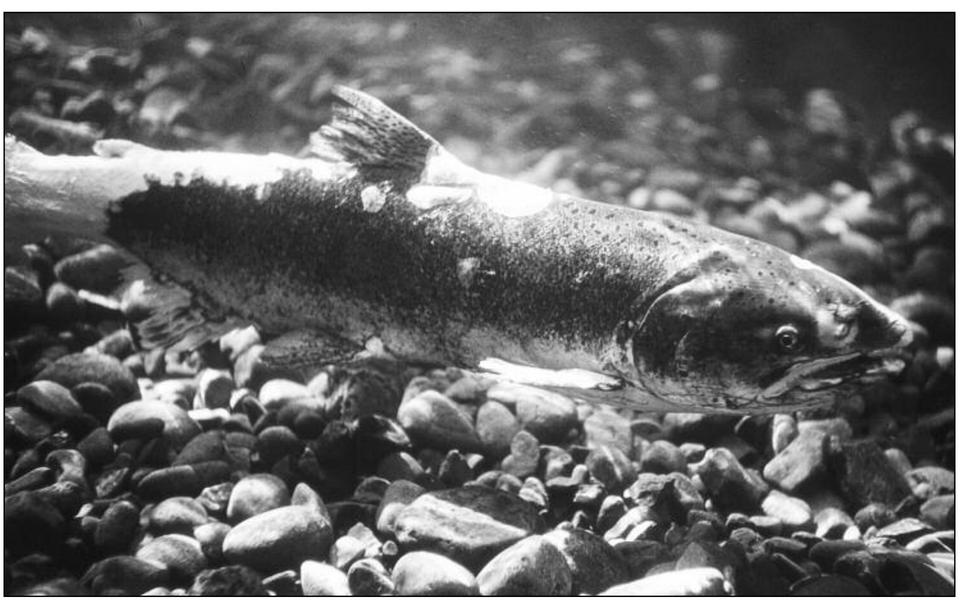
dition of the river changed substantially with the initiation of the Upper Willamette Project managed by the Army Corps of Engineers (COE). This project was intended to provide flood control, irrigation support, hydropower, and recreation opportunities in the Willamette Basin. The project ultimately resulted in the construction of 13 dams, starting in 1942 and completed in 1969. In the McKenzie River two dams, Blue River Dam on Blue River (1969) and Cougar Dam on the South Fork McKenzie (1963), were constructed. In addition, Trail Bridge Dam (1963) blocked the mainstem of the river for fish passage at river mile 82. The latter dam was constructed by a local utility company and is intended to provide power to the metropolitan area downstream. The same utility also owns Leaburg Dam on the McKenzie River, three miles east of the town of Leaburg. It was built in 1929 to divert water from the river's mainstem to a hydropower plant. The water is subsequently returned to the river downstream. As the dam is of low height and has a functioning fish ladder it is not considered a serious impediment to fish passage. In total, these dams denied fish passage to about 40 miles of potential Chinook spawning habitat.

After dam construction was completed the number of naturally spawning Chinook in the McKenzie River continued to decline from the post-WW II baseline. The estimate for 1990-2005 was an average 2,104 wild Chinook returning annually. Most of the blame for the continuing decline has focused on the dams. However, while there is little doubt that the dams have contributed, they block access to only about 20% of the potential spawning habitat in the McKenzie basin, failing to completely explain the approximately eight-fold decline in the wild salmon population. Still, as dams were the most visible change and very likely had some impact, they seem to have become the preferred culprit. As a result, the COE and the State of Oregon agreed that as mitigation, the federal government would support McKenzie Hatchery production of about 840,000 smolts, based on the number of returning salmon that the dammed rivers were assumed to have otherwise contributed. The COE maintains ownership of the hatchery, which is managed under contract by ODFW. The number of Chinook smolts released in the McKenzie River from this hatchery averaged about 1,200,000 annually from 1990 to 2011, with ODFW funding production of the excess over 840,000.

Despite the concept that hatchery output was intended to "supplement" the native spawning Chinook numbers in addition to mitigating lost angling opportunity, there has been little or no evidence of a positive effect on wild Chinook salmon recovery. On the contrary, the fishery science literature has increasingly demonstrated that in most instances interaction between hatchery-origin and naturally-spawned anadromous fish exert strong negative effects upon the wild fish population. As the evidence has accumulated, attention of the scientific and conservation communities has progressively turned to the likelihood that hatchery operations are a major contributor to the demise of wild populations. (Araki and Schmidt 2010) Such harmful effects were already well known by 1999. In that year, as the number of McKenzie Chinook dropped below 1,500 spawners, the National Oceanic and Atmospheric Administration (NOAA) listed the spring Chinook salmon in the entire Upper Willamette Basin as threatened under the Endangered Species Act (ESA) and designated the spring Chinook salmon an Evolutionarily Significant Unit (ESU) of their species. Following listing, the agencies (in this case the COE, Bonneville Power Authority (BPA) and Department of Reclamation) responsible for managing the species were required to provide a Biological Assessment (BA) of the status of the species, factors contributing to its being threatened, and corrective actions that will lead to the species' recovery. This document was prepared and sent to the section of NOAA that oversees these issues, the National Marine Fisheries Service (NMFS), which has the authority to approve programs or require changes it judges as "prudent and necessary" to improve the situation. Beyond the BA, a hatchery program that could harm the listed ESU requires submission and approval of a Hatchery Genetic Management Plan (HGMP) that defines the boundaries of the program, and describes actions that will be taken to assure that there are no effects that are significantly detrimental to recovery of the wild stock. Further, NMFS regulations require systematic monitoring of the status of the listed species or stocks so that trends, positive or negative, can be identified and the consequences of actions determined. Thus COE submitted a BA and draft HGMP to NMFS for review and comment. A program for



A wild spring Chinook salmon on spawning beds in the upper McKenzie River, Oregon. Photo by Jim Yuskavitch

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systematic monitoring of the status of Chinook salmon in the basin was put in place and executed by ODFW under contract with the COE.

The key issues specific to the McKenzie River identified in the BA and subsequent responses from NMFS were the following:

• Provide fish passage for Chinook salmon at Cougar Dam to reestablish the South Fork run.

• Modify the release of water from the project dams to reduce impact upon spawning and rearing of salmon below the dams.

• Reduce genetic introgression (interbreeding) between wild and hatchery stock. At that time the plan was to capture all hatchery-origin fish that did not return to the hatchery before they could cross Leaburg Dam into the upper river, thereby creating a "wild fish sanctuary" for native spawners above the dam.

• Create a systematic monitoring program consistent with the ESA requirements. This would include fin clipping, and later otolith marking to confirm whether a fish was truly naturally spawned even if it appeared not to be clipped.

• Based on new standards for reducing potential impact of gene exchange between wild and hatchery stocks, increase the incorporation of wild spawners to about 20% of the broodstock (i.e., create an "integrated" hatchery stock).

The various agencies' responses to these requirements were at best mixed. Some progress was made in setting new standards for release of water from project dams, and a monitoring program was initiated to track the status of native spawning Chinook and the numbers of hatchery fish that escaped to spawn. However, there was no tangible progress in establishing fish passage at Cougar Dam. The newly-implemented monitoring program documented that the level of genetic introgression continued to be unacceptably high. The number of wild Chinook continued a downward trend. On the administrative side, NMFS had not accepted the originally submitted BA, and there was no HGMP agreed to by all the participating parties.

As a result of this lack of progress, in 2007 the Willamette Riverkeepers and the Northwest Environmental Defense Center filed a complaint in federal court contending that the involved federal agencies were in violation of the ESA for not completing the required program documents or actuating the programs. In early 2008, the agencies settled the case, with NMFS agreeing to produce a Biological Opinion (BiOp) in response to the various drafts of HGMPs; that the COE would proceed with their Cougar passage project; and the effort to reduce genetic introgression by removing hatchery strays at Leaburg Dam was to proceed. This resulted in an Upper Willamette Basin 2008 BiOp from NMFS which stated the action items and timelines for completion, and the COE produced a new BA because the prior document was now obsolete. Notably, the issues and their proposed solutions did not change much from what had been discussed during the previous 8 years, though the data accumulated over this time reinforced the need for action.

In 2011 NMFS and ODFW produced a document entitled "Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead" (http://www.nmfs.noaa.gov/pr/pdfs/recovery/chinook_steelhead_upperwillametteriver.pdf), which generally covered the requirements of the BiOp but largely omitted firm time frames for achieving these goals, or penalties for failing to do so. During their preparation of public comments on this document, the McKenzie Flyfishers and Steamboaters became concerned by the lack of progress on implementing actions specified in either the 2008 BiOp or the 2007 settlement agreement. For instance, while the BiOp stated that the percentage of hatchery origin spawners (pHOS) in the McKenzie River should be < 10%, the observed values consistently averaged around 40% or more for the river below Cougar Dam; and the major plan for reducing pHOS, involving installation of a hatchery/wild fish sorter at Leaburg Dam, had been abandoned as infeasible. Further, the dates set by the 2008 BiOp for downstream passage of fish spawning above Cougar Dam had come and gone; and the program for incorporating native spawned Chinook into the hatchery broodstock was not being followed.

Equally concerning was the lack of any credible programmatic response to a rapidly evolving scientific literature demonstrating the surprisingly severe impact of hatchery origin fish spawning in the wild, or to new molecular tools for monitoring these effects on natural populations. For example, recent papers have raised serious questions regarding the ability of "integrated" hatchery practices to avoid reduction in reproductive performance among wild spawners. (See for example, Chilcote, M. W., K. W. Goodson, and M. R. Falcy. 2011. "Reduced Recruitment Performance in Natural Populations of Anadromous Salmonids Associated with Hatchery-Reared Fish." *Canadian Journal of Fisheries and Aquatic Sciences* 68 (3): 511–22. doi:10.1139/F10-168.) One conclusion that can be drawn from this analysis is that the effective population size (Ne) of naturally spawning salmonids is substantially smaller than the total number of spawners. This subject warrants considerably more analysis but it should caution us that just counting redds and carcasses may substantially misstate what is going on in the rivers and mask issue which arise from small breeding populations (e.g., inbreeding, allele loss and adaptation to changing environments). (Allendorf, Luikart Aitken, 2013)

Based upon the above information, we concluded that continued high levels of genetic introgression could threaten the viability of the McKenzie River Chinook ESU regardless of prior assessments of this risk. Following discussions with each of the agencies involved in managing this fishery, and with support from the Western Environmental Law Center, in December 2013 the McKenzie Flyfishers and Steamboaters filed a complaint in Federal Court alleging that the COE and ODFW were in violation of the ESA and its associated administrative requirements. The complaint alleged that the agencies operated the McKenzie Hatchery for

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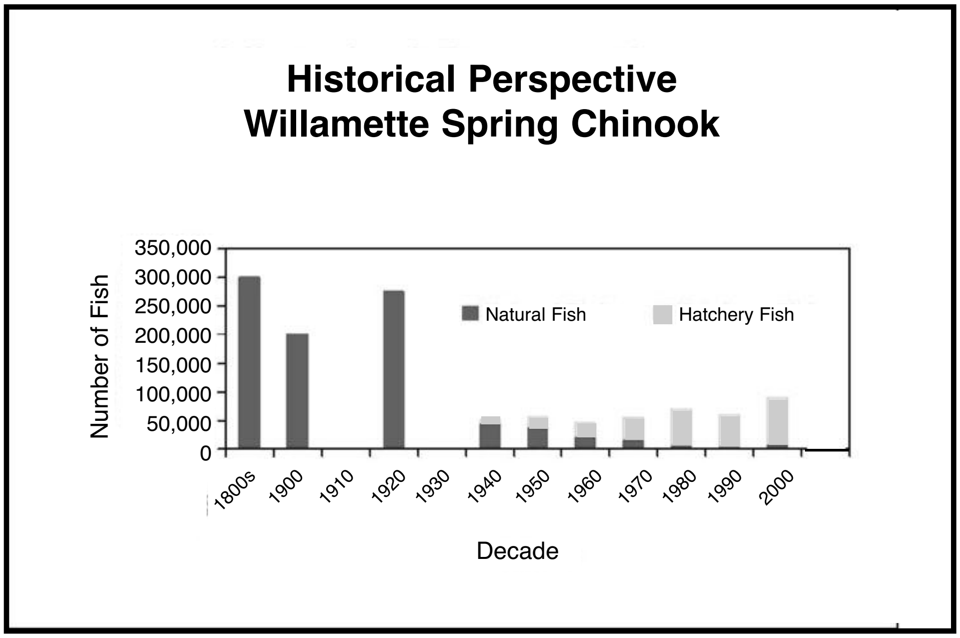

years without an approved HGMP; allowed a genetic introgression level of at least four times the limit set by NMFS; and failed to establish fish passage at Cougar Dam, despite the requirements set out in the 2008 BiOp. The plaintiffs asked for a summary judgment barring the release of more than the number of Chinook smolts needed for conservation purposes (reestablishing a spawning population above Cougar Dam) until there was an approved HGMP defining the scope of the program. The matter was set for a settlement conference in June 2014. That process resulted in the COE and the plaintiffs agreeing to an immediate three-fold reduction in Chinook smolts released into the McKenzie River, the COE's submission of an updated HGMP for the McKenzie Hatchery to NMFS within 45 days, and their final decision on the program for fish passage at Cougar Dam no later than March 2015.

However, ODFW refused to settle the case and it ultimately went before a federal judge in Eugene, Oregon at a hearing on March 2, 2015. The judge's ruling, released on March 13, denied the plaintiffs' request for summary judgment and injunctive relief, on the grounds that there had been correspondence between ODFW and NMFS indicating that the latter found ODFW's proposed program appropriate, and thus ODFW was protected from liability. Based on this reasoning, the court also accepted ODFW's right to release the 605,000 smolts that they were proposing. This number effectively cuts the smolt release number in half from the historic program levels, and should have some positive effect on reducing genetic introgression. Importantly, however, the court also affirmed, as did the court in the similar Sandy River Case, that the evidence accepted by all parties clearly confirms that genetic introgression between hatchery origin and wild fish of the same species harms the latter. Further, the judge ruled that the target set in the 2008 BiOp for the maximum acceptable genetic introgression, as measured by the pHOS proxy, must be met in a reasonable time frame acceptable to the court. Specifically his order states that "…the defendants need to understand that this may not be kicked down the road endlessly. Accordingly, the court intends to oversee this process to ensure that the target is met in a realistic time frame." The court stated that its ruling in favor of ODFW is "contingent upon defendants consulting with NMFS to establish a time frame for defendants to achieve a less than ten percent pHOS and submitting a proposal of the deadline to this court for approval. Defendants have ninety days to submit the proposal to the court."

We are disappointed that the court did not find ODFW liable for ESA violations, but feel that the court's finding that genetic introgression is harmful to endangered fish is an important precedent, with implications for many issues involving anadromous fish. We are also gratified that the court is maintaining jurisdiction over the development of critical corrective actions to the management of this fishery. At the same time, we observe that the COE has not yet announced a decision on whether to complete a project for downstream fish passage at Cougar Dam, despite the commitment they made in the 2014 settlement agreement. Also, ODFW recently submitted its own HGMP for the McKenzie Hatchery independent of the COE, even though COE owns the hatchery and has always been regarded as the agency primarily responsible for HGMP submissions. COE has objected to the approval of such a document, asserting that ODFW has no standing in the process. We are currently monitoring the situation.

Today it's generally agreed that, of the various stocks of Chinook salmon in the Upper Willamette Basin, it's likely that only the Clackamas and McKenzie River stocks are sufficiently productive to avoid extirpation; and that the McKenzie River population is the most genetically intact and most likely to be the source of recovery of these iconic wild fish. Sadly, although the conservation value of these fish is unquestioned, the escapement has continued to drop over the past 12 years and in 2014 was at the lowest number of natural spawners ever observed on the McKenzie River.

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Wild Fish Victories on Washington's East Fork Lewis River

By Steve Jones
— Clark-Skamania Flyfishers —

Author Steve Jones is President of Clark-Skamania Flyfishers. Founded in 1975, the group's members are tireless advocates for wild fish, habitat and conservation on the lower Columbia River and its tributaries. To learn more about them, visit their website at: www.clark-skamania-flyfishers.org/index.html

Many are attracted to fly fishing in their search for a way to pursue a fish without consuming it. To them, catch and release makes sense. When your prey swims away to fight again, angling becomes a better way to enjoy a river or a wilderness or an afternoon away from the job. People become fly fishermen when they realize that fly fishing is not about how to fish, it's about how to be.

It's about giving back to the lake, sharing what you know, picking up your litter, fencing the cattle out of the river, restoring the meandering tributary, replanting the banks, conserving the water, removing the invasive species, reestablishing the native fish. Without conservation, fly fishing risks becoming quaint or merely picturesque. With conservation at its core, fly fishing can create an energetic community of anglers like Clark-Skamania Flyfishers.

The club was founded in 1975 by fishermen concerned about the declining quality of water and fishing on the Washougal River in Clark County, Washington and the Wind River in Skamania County to the east. Since its founding, the club has had a conservation director among its regular officers. Conservation directors, such as Mark Heirigs today and past directors Craig Lynch and Dennis Ward, work to keep the club abreast of fisheries issues. Today the club has 176 members and regularly draws about 100 to monthly meetings where conservation

Conservation is the core of flyfishing that creates an energetic community of anglers.

is a regular part of the discussion. It's also a regular part of the action.

On a weekday morning in December, 2014, about a dozen club members milled around offices of the Washington Department of Fish and Wildlife Lewis River hatchery. Many of them were regulars at this event. They sipped coffee and swapped stories about recent outings and lousy weather. Ed Wickersham, a long-time CSF member and past president, stepped out of the office to announce they would be handling four bins of salmon carcasses that day, nearly 1,000 fish. All would be distributed in the East Fork Lewis to the south. After trucking the totes to the river, the work is done by hand. Using a pike, a hoe-like tool with a spike on the end, a club member spears each fish and tosses it into the water at various points along the river. Decomposing carcasses add nutrients to the river, which provide food for bacteria and insects at the base of the aquatic food chain steelhead need to thrive.

Logged, burned, mined, over-fished and over-developed, the East Fork Lewis River has gone from a source of legendary steelhead runs to a river crowded with hatchery plants and vague promises that one day the natives would recover. By the 1990s, the native steelhead had dwindled to endangered status. In the mid 2000s CSF members began volunteering to place hatchery carcasses in the East Fork to replace the biomass lost from

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Members of the Clark-Skamania Flyfishers place salmon carcasses along the East Fork Lewis River as part of the stream enrichment program. Photo by Steve Jones

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native runs and give what natives remained a source of nutrients. Now CSF members lead the effort, which has placed more than 10,000 carcasses in the East Fork so far this year.

CSF also participated in a detailed two-year evaluation of the East Fork that resulted in its designation as one of three gene bank tributary rivers of the lower Columbia River for winter and summer run steelhead. And earlier in 2014 when CSF members were alerted to a potential logging operation on private land adjacent to a popular East Fork campground, the club quickly joined Friends of the East Fork, a local environmental group, in an appeal to Washington State land use officials. Simultaneously, Friends of the East Fork began searching for a conservation buyer for the tract. As land use officials began uncovering problems with the logging plan, the landowner changed his mind about cutting and sold the land to a conservation buyer.

And CSF is putting its money where its mouth is too. The club has made more than $8,000 in grants during the past decade to conservation work on the East Fork. It will join with others to help finance another East Fork restoration project in 2015.

Money for such efforts comes from the annual CSF Banquet. The club has held an annual fundraising banquet for 38 years and in that time has raised and donated more than $185,000 to conservation and outreach efforts. Most of the club's spending is focused on conservation in Washington and the lower Columbia River basin. CSF has used its cash to support like-minded environmental groups such as the Gifford Pinchot Task Force in its fight to prevent mining on Green Mountain, in the headwaters of the Lewis River. And to help introduce new generations to fishing and conservation the club has supported the local Klineline Pond kids fishing day since 2008 and the Salmon in the Classroom program since 2009.

One of CSF's most recent contributions to wild fish conservation was its $15,000 grant to the Columbia Land Trust for its effort to protect critical bull-trout habitat on Pine Creek, a Lewis River tributary. Those funds were used by the land trust towards the purchase of more than 2,800 acres of forest and riparian land that, when combined with a previous 2,330-acre purchase, now protects nearly the creek's entire upper watershed.

When you fly fish you come to appreciate every day miracles. You can go through a run time and again with no results and then be surprised with a rambunctious big fish. Good fly fishers understand the better fly they tie, the better cast they present, the better chance of a fish pulling tight on that line. For a generation, members of CSF have understood the better stewards we become, the better environment we create, and the better we all are for it.

Clark-Skamania Flyfishers contributed $15,000 to help the Columbia Land Trust purchase property along Pine Creek, an important tributary of the Lewis River. Photo courtesy Columbia Land Trust

Sorry about that

We misidentified U.S. Congressman Jared Huffman in S. Craig Tucker's article on the Klamath River dams in the January 2015 issue of *The Osprey*.

Congressman Huffman is a Democrat who represents California's 2nd District. We apologize for the error.

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By either means, the steelhead and salmon will thank you for supporting *The Osprey*.

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Club entitled "Kindred Spirits" [or some title very similar].

Recent reports of efforts on two fronts caught my attention as they regard the thesis offered by "Kindred Spirits":

• Klamath Basin Restoration Agreement [KBRA]. KBRA would change and share water distribution in the Klamath Basin and set the stage for removal of dams thus opening many miles of habitat for migratory fish. It is official that Lower Klamath National Wildlife Refuge, [founded during the Theodore Roosevelt presidency as the first refuge for migratory waterfowl], will receive no water this year. [Many will recall the salmon kill of 2002 in the Klamath River. I have received a copy of the April 20, 2015 letter to three Congress members (including mine) signed by numerous organizations and businesses urging Congressional approval of the (years in the making) agreement. These include: national & state fisheries and waterfowl advocates, Northern California Council of the IFFF, plus commercial fishing interests & recreational fishing guide services/shops. There were 37 signatories total.

• Theodore Roosevelt Conservation Partnership (TRCP) on the potential sale of public lands. "WHAT'S AT STAKE" "OUR LANDS FOR SALE""America's 640 million acres of federal public lands – including our national forests and Bureau of Land Management lands – provide hunting and fishing opportunities to millions of Americans.

"Without these vast expanses of prairie and sagebrush, foothills and towering peaks, the traditions of hunting and fishing as we have known them for more than a century would be lost.

"Efforts are afoot across nine Western states (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah and Wyoming) to wrest public lands from the federal government and put them under state ownership.

"States are simply not equipped to shoulder the enormous costs associated with fighting wildfires, maintaining roads and trails, treating noxious weeds and conducting habitat restoration.

"The transfer of federal lands to the states would result in one likely outcome: the fire sale of these lands to the highest bidder – billionaires and foreign corporations who may neither understand nor value America's outdoor heritage. Once privatized, these lands will become off limits to most sportsmen in perpetuity."

I posted a Facebook comment regarding the TRCP item similar to this: "If Hunters- Fishermen/Women-Environmentalists joined together, the coalition would be unstoppable." This is the core concept of the "Kindred Spirits" article.

To my surprise, a reply came from TRCP pointing me to the "Partners" page of their website. The list includes 43 total organizations. Three on the list are ones to which I'm a Life Member including the International Federation of Fly Fishers. Two more I've been an annual member for years. And another half dozen are organizations I feel an affinity towards.

Some of the organizations involved in both cases have paid Washington DC staff, permanent office headquarters also staffed.

While both lists of partners are truly substantial, the number of "Kindred Spirits" in my imagination is much larger. These two are examples the concept is building. However, we've still got a ways to go to build the unstoppable coalition working and protecting diverse environments. The unstoppable coalition that naturally would support wild salmon and steelhead!

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