The Case for Breaching the Four Lower Snake River Dams to Recover Wild Snake River Salmon

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You can always count on Americans to do the right thing - after they've tried everything else. ~ Winston Churchill

Salmon are keystone species, critical to preserving the Snake River ecosystem. All four Snake River wild salmon runs are threatened with extinction and listed as threatened or endangered under the Endangered Species Act. The four lower Snake River dams are a major cause.[2] Recovery measures for wild salmon costing billions of dollars have failed. Problems inherent in the huge slack water reservoirs created by the dams cannot be fixed. The reservoirs have flooded out the natural river flows and riparian habitat, destroyed spawning grounds and rearing habitat, decreased river flow, and exposed juveniles to a host of aquatic predators and pathogens that thrive in the reservoirs. As a result, ***wild salmon are not meeting even minimal survival goals, much less recovering***.[3] This is despite a decade of favorable ocean conditions. Dam breaching offers the only opportunity to recover the natural flowing Snake River and its wild salmon, and with them, the Snake River ecosystem. All other previously identified recovery measures have been tried. It is time to do the right thing and breach the Snake River dams. To meet survival goals and provide wild salmon a fighting chance to recover, dam breaching must begin immediately.

Introduction

Snake River salmon recovery under the Endangered Species Act (ESA) is based on ***wild salmon*** surviving and recovering. Recovery is based upon a minimum number of spawning adults returning from the ocean to their native rivers and tributaries. Returning wild fish estimates have been masked, especially recently, by the increasing number of returning hatchery produced fish. Hatchery fish were intended as a temporary mitigation measure for producing harvestable fish due to anticipated losses from the construction of the dams and reservoirs. While hatchery fish runs are for the most part increasing, the native wild runs are remaining at dangerously low levels, if not declining. Despite three decades of studies and billions of dollars spent on anything but breaching the dams, wild populations have not experienced gains since they were listed under the ESA. More studies and more money are not the answer.

Reports of record wild salmon runs returning to spawn in the Snake River and its tributaries are greatly exaggerated. In 2014, for example, Will Stelle, administrator of NOAA Fisheries' West Coast Region ("NOAA") reported on the status of the threatened Snake River sockeye run, declaring that "[t]his is a real American endangered species success story," when 1,516 sockeye returned to the Sawtooth Basin in Idaho.[4] A year later NOAA told an entirely different story. Only 39 adult sockeye returned to their natal spawning ground in Redfish Lake.[5] Another 51 were trapped at Lower Granite Dam, the most upriver federal Snake River dam in eastern Washington.[6]

An additional six sockeye were trapped at a hatchery in the Sawtooth Basin.[7] The 96 sockeye were then trucked to a hatchery in Eagle, Idaho for genetic sampling. These sockeye were the survivors of the estimated 4000 fish in the Snake River population, in the larger than average 500,000 adult sockeye run that had entered the Columbia River. ***Lethally warm water in the Columbia and Snake Rivers killed up to 90% of those fish. Now NOAA estimates that recovery of Snake River sockeye could take 50 to 100 years.***[8]

Add this to the fact that for all the claims of "record" Snake River salmon runs for the last several years, more than 80% are hatchery fish, not the endangered or threatened wild salmon.[9] For the returning fall Chinook hatchery fish, in recent years, approximately 55% were hatchery surrogates for wild fall Chinook. The surrogates were bred in a special research project that began in 2005, the principal purpose of which was to assess the effects of different forms of juvenile fish passage through or around the dams.[10] Surrogates were needed because there simply were not enough wild fall Chinook for the research project. The surrogates were fall Chinook that were held over in hatcheries to feed, grow and outmigrate as special subyearlings.[11] As a result, the "record" returns of the last several years were actually runs that had been bumped up by a huge influx of large juvenile surrogate fall Chinook hatchery salmon.[12] The last surrogates were released in 2012. Fall Chinook returns will likely decrease accordingly, as the adult surrogate returns diminish.

Further, despite the number of salmon that enter the Columbia River and are counted at Bonneville Dam, the salmon that make it to the spawning grounds and spawn in the Snake River or its tributaries number in the tens, hundreds, or a few thousand, depending on the species, river or stream. Only a small percentage of these spawning fish are of wild origin.

An artificial hatchery system cannot replace wild fish runs in the long term. Due to the lack of genetic diversity, hatchery fish populations ultimately will collapse, ending most tribal, recreational, and commercial fisheries. In contrast, the genetic diversity of wild salmon is their strength. It gives them their resiliency and ability to adapt. ***On the Snake River hatchery fish are being allowed to dilute the wild gene pool at a faster rate than in previous decades***, ***which makes wild salmon more susceptible to population crashes***. Over millions of years, each wild salmon population has uniquely adapted genetically to its natal river or stream. Because there is a scarcity of wild salmon returning to spawn, genetically inferior hatchery fish are being released to spawn with wild salmon, which can result in less resilient offspring.[13] The gene dilution cycle is accelerating as some salmon spend only months or a year in the ocean, before returning to spawn. This leads to ever smaller fish. Sixty to eighty pound fish, are rarely, if ever, seen, while an increasing number of earlier "jacks" "mini-jacks" and now "micro-jacks" (8-10 inches) return in as little as four or five months. The offspring of hatchery and wild salmon are termed "natural" fish. The inferior genetics of the "natural" fish are passed on to wild fish, when the "natural" fish return to spawn.[14] Genetic dilution must be ended as soon as possible, so there will be enough wild salmon left to recover. This means that dam breaching must be accomplished in the immediate future, especially with rapidly increasing climate change,[15] to prevent Snake River wild salmon from becoming extinct.

Background
At over 1,200 miles in length, the Columbia River is the fourth largest river by volume in North America, draining an area the size of France (259,000 square miles). The Snake River is the Columbia's largest tributary. It drains western Wyoming, half of Idaho, northeastern Oregon, and central and southeastern Washington, where it joins the Columbia at the Tri-Cities area in

Washington. ***Together the Snake and Columbia Rivers once produced more Chinook salmon than any other river system in the world. Hence, it has tremendous potential to do so again.*** Historically, ten to sixteen million wild salmon and steelhead ("salmon") returned each year to the Snake/Columbia River Basin. The Snake River Basin produced nearly half of these fish.[16] Today, about 1% of the historical number of salmon return to the Snake River watershed to spawn.

In the 1960's and 1970's the Army Corps of Engineers, Northwest Division ("Corps NWD") built four dams on the lower Snake River largely to allow barges to transport goods up and down the river from a port 465 miles inland at Lewiston, Idaho. While Lewiston was always questionable as a port,[17] barge traffic on the Snake River has been in decline for nearly 20 years and is declining at an accelerating rate today.[18] Although hydropower was a stated benefit added to compensate for negligible navigation benefits when the dams were authorized, the power was not needed then and remains surplus today.[19] In return for the little used and heavily subsidized navigation channel, the dams have wreaked havoc on the Snake River ecosystem, killing millions of wild salmon annually for nearly fifty years, by blocking or impeding fish passage through the river.

One species, Coho salmon, went biologically extinct in 1982. The dams also took a huge toll on fall Chinook salmon. They spawn in the mainstem of the Snake River. The dams turned 140 miles of the mainstem Snake River into slack water reservoirs, rendering only about 15% of fall Chinook spawning and rearing habitat usable.[20] Elimination of their spawning habitat affects every stage of fall Chinook fresh water life history, including adult migration, spawning, incubation, juvenile rearing and outmigration to the ocean. Moreover, the effects of the Snake River ecosystem destruction extend out to the waters of the Pacific Ocean. The dams have eroded the prey base of iconic marine mammals such as Southern Resident orcas who are starving periodically due to the lack of abundant Chinook salmon from the Snake River.[21]

Under the Endangered Species Act, the federal government has a legal obligation to recover the Snake River populations of threatened and endangered ***wild*** salmon.[22] As a result of NOAA Fisheries' 1995 Biological Opinion and subsequent Biological Opinions, the Army Corps of Engineers at Walla Walla conducted a multi-year study to evaluate the best way to improve juvenile salmon migration through the lower Snake River dams. The study, the *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement* (*Feasibility Report*),[23] included dam breaching as a means to recover wild salmon. This approach involved removing the earthen portions of the dams to create a free flowing river. All available science suggested that dam breaching presented the greatest biological potential for recovering endangered and threatened Snake River salmon and steelhead.[24] In 1999 the National Marine Fisheries Services (NMFS), now NOAA Fisheries, determined that for the Snake spring/summer Chinook, the ***most risk averse action*** would include dam breaching, a harvest moratorium, and vigorous improvements in habitat and hatcheries.[25] (*Emphasis in original*.) NMFS' results demonstrated that for Snake River fall Chinook and steelhead, ***dam breaching by itself would likely lead to recovery***.[26]

Despite the U.S. Fish & Wildlife Service (USFWS) finding that "[t]he benefits to fish and wildlife resources in the area of the four lower Snake River dams from drawdown [breaching] would exceed those provided by the other alternatives,"[27] the predetermined conclusion was that the dams would not be breached.[28] In 2002, after $33 million had been spent on the study, a political decision was reached based on heavily criticized economics that greatly overstated the costs of dam breaching and understated the benefits.[29] Notwithstanding breach recommendations by the USFWS,[30] and the

Deputy District Engineer for Programs at the Corps Walla Walla District, the Corps NWD announced to the taxpaying public that the dams would not have to be breached, if $350 million were spent on massive "system improvement" projects on the four Snake River dams to permit less hazardous juvenile fish passage. This would give the region time to determine if salmon survival and recovery could be effected through the non-breaching alternatives.[31] The Corps NWD projected that if the improvements were installed, the wild salmon runs that had been spiraling rapidly downward would be recovered. If these efforts did not succeed, the nine involved federal agencies (the Federal Caucus) agreed that dam breaching must be considered.[32] Ten years was the outside time period allowed for results.[33]

To avoid breaching the dams, the federal agencies have spent billions of dollars on ineffective mitigation efforts, with $700 million spent on "system improvements" just for fish passage at the four dams. At this date system improvements are poised to become even more costly, since they are aging and in need of expensive rehabilitation.[34] Further, system improvements at the dams do nothing to improve the slack water reservoir conditions, which are as lethal to salmon and steelhead as dam passage. The only effective means of addressing reservoir mortality is to drain them through dam breaching, and allow the natural flowing river regime to return.

The statement that began the *Feasibility Report*, Appendix M in 2002, that *"[d]espite considerable expense and management efforts, anadromous fish stocks in the Snake River Basin continue to decline*," is as true today as it was then.[35] This result should have been anticipated, since the Corps NWD's decision to maintain the dams failed to address the best available science, which mandated breaching the dams. Thirteen years have passed and wild salmon runs are not meeting survival goals, much less recovering. Dam breaching must be accomplished now for wild salmon to survive.

Salmon Are the Biological Foundation of the Snake River Ecosystem

Salmon directly support the watershed's food webs and riparian forests. They are a "keystone" species in both aquatic and terrestrial environments, influencing the survival and reproduction of other species. Salmon runs function as enormous pumps that transfer huge amounts of marine nutrients from the ocean to the headwaters of otherwise low productivity rivers. These nutrients are incorporated into food webs in rivers and surrounding landscapes by a host of well over 100 species, including mammals, birds, and fish that forage on salmon eggs, juveniles, and adults in freshwater. Insects, bugs, birds, and mammals, among many others, feed off the salmon carcasses.

Predators disperse marine nutrients into surrounding forests, enhancing the growth of streamside trees that shade and protect stream banks from excessive erosion. Nitrogen from salmon nourishes trees, shrubs, mosses, and algae, making the forests healthier. As the trees grow and age, fed by salmon nutrients, they contribute to the positive feedback cycle when they fall into salmon streams. There they provide shelter for juvenile salmon and protect the gravel that adults use for spawning. The reservoirs have erased these features.

Without marine nutrients from salmon, river ecosystems cannot thrive. Species diversity declines, trees wither and can no longer exchange CO_2 as effectively, forests become more susceptible to wild fires that emit enormous amounts of CO_2, and the carbon sinks in the watershed disappear. Recovering the once abundant salmon runs is important to the entire ecosystem.[36]

Salmon Biology/Ecology

Salmon are anadromous fish. They hatch in freshwater, then migrate out to the ocean as juveniles (smolts), to return as adults to spawn. Salmon migration requires river and stream flows sufficient to permit juveniles to travel downstream to develop and grow, and upstream for adults to spawn and reproduce. As juveniles migrate they "imprint" or memorize a complex map of the river, which helps them find their way back home. Once they reach the food rich sea, salmon grow quickly, increasing their weight over a hundred to a thousand times. After two to five years feeding in the ocean, salmon begin maturing and start their long migration home. Once they near freshwater, they rely on both their sense of smell and the map of the river imprinted in their memory to navigate home to the rivers and beaches of their birth. The very essence of the wild salmon's evolutionary development over thousands of years is finely tuned for this return journey. They rely on natural factors in the rivers, such as temperature, flow regimes, water movement and vibrations, predator-prey relationships, and water chemistry, all of which have been changed by the dams and reservoirs. Those that make it home in sufficient condition, spawn. After spawning, adult salmon die.[37]

Adult salmon rarely eat as they travel hundreds of miles upriver. They depend on their energy stores accumulated from feeding in the ocean. Dams and rising reservoir temperatures impede migration in a variety of ways, and prolong the journey, which makes less energy available both to reach the spawning ground and to spawn. Every obstacle takes its toll. Energy expended getting around dams and through the reservoirs is energy unavailable for spawning.

The downriver migration of juveniles is likewise complicated and treacherous. The four lower Snake River dams are particularly harmful to juveniles, since the 100 foot high dams were built largely without juvenile salmon fish passage features. Thus, the dams forced juveniles to pass through turbines or over spillways that killed many of them at each dam. Only Lower Granite Dam had design features for juvenile salmon passage. Even though the dams have been retrofitted to mitigate this harm, for most years less than 50% of any one ESA listed stock of smolts makes it out to the ocean.[38] Lower flow years can reduce survival to the ocean to less than 10%, principally due to much slower water velocities. This causes low fitness and missed timing of ocean entry, more restricted dam route passage operations, and more active predators that can hunt in the increased areas of slower water through the reservoirs.

The Current State of the Snake River Salmon Runs

The four ESA listed Snake River salmon runs continue to struggle to survive today. In recent years, even with favorable ocean conditions, hatchery supplementation, and many system improvements, none of the runs are recovering or meeting even the survival goals set by the Northwest Power & Conservation Council (NPCC), an interstate government agency charged with balancing the needs of salmon and hydropower.[39] Both returning adults and migrating juveniles are not surviving.

Returning adult wild salmon are crucial to their populations, because they are nearly ready to spawn and produce the next generation. Therefore, adults are important in determining whether salmon runs are surviving. The gold standard for measuring survival is the smolt-to-adult return rate, termed SARs. This is the rate of survival from the out bound smolt stage to the returning adult stage. It encompasses most of the salmon life cycle.

In 2009 (readopted in 2014) the NPCC set survival and recovery objectives for listed wild Snake River wild salmon populations at 2% to 6% SARs.[40] For example, SARs of 4% are necessary to meet the NMFS interim 48-year *recovery* standard for Snake River spring/summer Chinook, while meeting the interim 100-year *survival* standard requires a median SAR of at least 2%.[41] The overall SARs for Snake River populations of salmon are not meeting this goal.[42] During the 1990's and 2000's, Snake River wild steelhead SARs decreased nearly four-fold from pre-dam construction. Snake River wild steelhead and wild spring/summer Chinook SARs were well short of the NPCC objectives across the majority of years from 1964 to 2011.[43] As of 2006, Snake River Chinook life cycle survival rates declined to about 12% of pre-dam productivity.[44]

NOAA Fisheries reports for outmigrating juveniles show that salmon survival became even more precarious in 2015. In September, NOAA issued preliminary estimates of survival of PIT-tagged juvenile salmon and steelhead passing from the Snake River trap at the head of Lower Granite reservoir to the Bonneville Dam tailrace, during the 2015 spring outmigration.[45] The results were dire. For *hatchery and wild combined* juvenile Snake River yearling Chinook salmon, the estimated survival was 39.7%.[46] This is the third lowest survival rate since 1999 and the lowest estimate for Chinook since 2004.[47] For Snake River steelhead (hatchery and wild combined), NOAA estimated the survival rate at 36.1%.[48] This is the fourth lowest estimate since 1997.[49] For ***wild*** Snake River steelhead, NOAA estimated the survival rate at just 30.1%.[50] The estimated survival of juvenile Snake River sockeye salmon (hatchery and wild combined) from the tailrace of Lower Granite Dam (*below the dam*) to the tailrace of Bonneville Dam was 37.3%.[51]

Sockeye adults did not fare better in 2015. The Columbia and Snake Rivers became a killing field for the returning larger than average sockeye run. Due to drought, climate change and the dams, lethally warm water temperatures killed up to 90% of the returning Snake River sockeye salmon run to Lower Granite Dam. Only 45 sockeye made it through the Columbia and Snake rivers to return to the Sawtooth Basin in Idaho. This means that *an additional 90% of those passing Lower Granite Dam did not survive* to the Redfish Lake trap.

Facts—the Four Lower Snake River Dams Kill Salmon

- **Dams flood out salmon habitat**. Fall Chinook salmon spawn on the mainstem of the Snake River. The dams have flooded about 85% of the 140 miles of mainstem spawning habitat.[52]
- **Dams kill or stun juvenile salmon as they pass through or over the dam structures.** Physical injury, including brain damage, resulting from impacts with spillway structures and turbines, as well as hydraulic forces associated with spill and sudden depth changes are some of the main hazards associated with hydropower-related passage. Studies of the effect of exposure to severe hydraulic events on juvenile salmon have found a variety of adverse effects caused by strike, shear, pressure gradients, and disorientation. Recent studies have found that fish exposed to high shear and turbulence are subject to direct injury and are more susceptible to bird and fish predation than migrating salmon that have non-turbulent passage.[53] Some of these detrimental effects are realized as delayed mortality, mortality that occurs after fish pass Bonneville Dam as juveniles that would not occur if the federal hydrosystem did not exist.
- **Fish ladders impede adult salmon moving upriver.** Fish ladders have narrow entrances that are difficult to find, and entry can be precluded by extremely large flows over spillways and tailrace discharges from hydroelectric turbines.[54] This can delay migration to spawning areas. Once salmon have traversed the ladders, they must avoid fallback, being swept back over the spillway or into the turbines where they can be torn apart. In addition, the water at the bottom

of the ladders tends to be cooler than the water at the top. As salmon climb the ladders, they encounter warmer water that is drawn from the top layer of the river above the dams. When temperature differences reach a certain level, salmon are more likely to hold up at the dams and wait for cooler water.[55] Any delay in passing, especially in warmer and turbulent tailwaters, depletes critical energy reserves required to finish migration and spawn.

Dams increase water temperatures and disease. The Snake River dams heat up the river by decreasing river flow and by creating slack water lakes that soak up the sun and become heat reservoirs.[56] Salmon become stressed once river temperatures reach the mid-60's Fahrenheit. Temperatures become lethal to salmon when they exceed the low-70's Fahrenheit. The four Snake River dams can add 6 to 12 degrees Fahrenheit to water temperatures.[57] The high water temperatures caused by drought, climate change and dams proved to be catastrophic to migrating sockeye in 2015. Warm river temperatures also harm salmon by increasing disease and degrading water quality.

- **Dams provide ideal conditions for predators.** The dams have changed a cool, swift river to deep, warm, low flow reservoirs that favor certain species, such as the northern pike minnow, and smallmouth bass.[58] The longer the migration in the warmer slack water reservoirs, the higher the loss of salmon to these predators. Pike minnows are voracious feeders and can consume several dozen juvenile salmon per day. Expensive pike minnow bounty programs have not controlled their population or predation. Further, there are few, if any, effective mitigation measures in place for the well established predation losses of juvenile salmon to non-native smallmouth bass, largemouth bass, walleye, and several catfish species.
- **Dams interfere with juvenile salmon physical development, which, in turn, interferes with their ability to adapt to the marine environment**. Juveniles undergo a complex transformation that involves physiological, biochemical, morphological, and behavioral changes (smoltification) as they migrate downriver. This allows juveniles to transition from living in freshwater to living in saltwater. Both the slow moving water in the reservoirs and navigating around or through the dams delay the outward migration of juveniles, which can interrupt smoltification. Transporting juveniles disrupts and interferes with smoltification timing, resulting in delayed mortality after smolts are discharged below Bonneville dam.
- **Dams lengthen the juvenile downriver migration time**, **a large factor in juvenile salmon mortality.** Salmon are genetically programmed for a one to two week swim to the sea, swept downriver tail first by the cold, fast-flowing water associated with spring snow melt. Now juvenile salmon may take one to two months trying to find their way downstream, making them subject to predation, warm water, disease, and delayed smoltification.

Dam "Solutions" Don't Work

"Fish passage system improvements" haven't worked. Many expensive dam modifications and surface passage structures have been designed and installed, yet wild populations still are not meeting minimum survival objectives.[59]

Habitat improvement without more doesn't work. Restoring tributary, mainstem and estuary habitat was the key to the Federal Caucus salmon recovery plan.[60] More than two decades of effort establishes that habitat improvement in the tributaries, without significant flow increases in the mainstem lower Snake River, will not permit salmon to recover. Indeed, "*NOAA Fisheries* *acknowledges that the benefits associated with habitat improvement may not accrue for many years, if ever*."[61]

Hatcheries don't work to recover wild salmon. For all intents and purposes, wild Snake River sockeye, from a genetic integrity standpoint, already are extinct since there are so few remaining. Those that remain are all in a hatchery production facility that generally produces quite smaller spawners. These fish are incapable of catching up on their own in a wild environment to reach sustainable survival and recovery goals. In addition, the wild component of the other stocks have been allowed to become inbred to such a degree that, at this point, they are being managed to extinction or extirpation. This point is crucial to recovery. Inbred or hatchery fish cannot survive more than a few generations. In contrast, genetically wild salmon runs are survivors, except in the most degraded habitat.

Wild salmon runs are comprised of hundreds of smaller unique breeding populations that are adapted to their home or natal streams. Each breeding population has genetic differences, termed genetic diversity. Wild salmon genetics drive production of Pacific salmon. Even within a single watershed, populations of fish spawning in different habitats often show remarkable differences in adaptive traits including spawn timing, size and age at maturity, and behavior, in addition to differences in their genetic makeup. Genetic diversity gives wild salmon their resiliency and ability to adapt to environmental challenges such as climate change, poor ocean conditions, high water temperatures, and parasites or pathogens. Wild salmon genetic diversity is being diluted at a faster pace, increasing the chances of wild species extinction.

In the Snake River Basin, hatchery propagation of spring/summer Chinook salmon and steelhead went into mass production during the 1970's and 1980's in response to lower Snake River Dam construction, as mitigation for the fish losses caused by Ice Harbor, Little Goose, Lower Monumental, and Lower Granite Dams.[62] Hatchery production now dwarfs natural production. Approximately **92%** of all salmon and steelhead smolts leaving the basin, and **85%** of adults returning to the basin, are of hatchery origin.[63] The pervasiveness and magnitude of hatchery production in the Snake River Basin is a direct cause of the decline of these wild populations.[64]

Hatchery salmon harm wild salmon by breeding with them. Hatchery "supplementation" programs allow hatchery fish to breed with wild salmon in the rivers to create "natural" fish, a cross between wild and hatchery fish.[65] Supplementation is used extensively. This practice dilutes the wild salmon's genetic diversity and size advantage, making wild—now "natural"—salmon more susceptible to population collapse from adverse conditions.

Hatchery fish further harm wild salmon by competing for a finite supply of food and habitat and by transferring diseases.[66] The millions of juveniles released from hatcheries seriously diminish the food supply available for wild juvenile salmon.

Due to the influx of jacks and the dilution of the wild gene pool by hatchery fish, the overall size of individual fish returning to the Snake River and its tributaries has been declining. As a result, it is becoming increasingly unusual to observe Chinook salmon in the 20-50 pound range.

Barging and trucking juvenile salmon around dams has not increased the wild salmon populations. To mitigate salmon mortality, for nearly three decades the Army Corps of Engineers, Walla Walla District has engaged in a juvenile salmon transport program that takes salmon out of the river. The Corps NWD collects juvenile fish via complex highly engineered bypass systems in and around the dams, and then deposits the juveniles into barges or trucks to ferry them 300 miles downstream past dams, to avoid the mortality the juvenile salmon would incur by passing through multiple dams. Once discharged below the dams, those fish that survive resume their trip to the ocean, often in a traumatized condition that disrupts their ability to adapt from fresh water to marine water, and causes delayed mortality. Transported fish that do survive and return to the river as adults are impaired, since the transport deprived them of the opportunity to imprint the complex river map that helps them find their way back home. Although the federal agencies have claimed that there is a high survival rate for juveniles transported out of the river, this claim is belied by the consistently low smolt to adult survival ratios.

Severe reductions in commercial and sport fishing have not halted the decline of wild salmon populations. Mainstem Columbia River harvest rates decreased markedly in the 1970s following construction of the four lower Snake River dams and the subsequent decline in abundance and productivity of upriver Columbia and Snake River populations.[67] For example, Idaho has not had a general salmon fishing season since 1978. Ocean harvests have been severely restricted for decades. Despite these reductions, Snake River wild salmon runs are not meeting survival goals.

Increasing "spill" over the dams to aid juvenile migration downriver has not recovered the salmon runs. "Spill" is the Corps term for increasing water flows over the dams. Court ordered "spill" and favorable ocean conditions have increased the abundance of some salmon runs, but not sufficiently to meet survival objectives, much less recovery goals. Breaching the dams is the ultimate "spill" that would return the Snake River to near natural conditions. Breaching is the most certain way to increase Snake River wild salmon. Further, additional spill on two of the Lower Snake River Dams, Lower Granite and Little Goose, may increase juvenile mortality due to design flaws in the dam structures regarding the spillway/tailrace hydrology. This can be remedied only by breaching the dams.

Breaching the Lower Snake River Dams Would Recover Salmon

Breaching the dams would go a long way towards remedying all the problems discussed above, because it would restore the natural Snake River ecosystem. The many benefits have been well studied and are set forth explicitly in the 2002 *Feasibility Report,* Appendix M.[68] Dams would no longer be creating problems. Phasing out hatcheries, once the wild salmon runs return to greater abundance, would eliminate the dangers posed by hatchery fish. A natural flowing river would restore habitat. To give habitat a further boost, as hatcheries are phased out, hatchery jobs could be switched to habitat restoration and recreation-related jobs. Harvest should remain restricted until wild runs have recovered sufficiently.

Immediately, a benefit to breaching the dams would be the recovery of more than 140 miles of mainstem fall Chinook spawning habitat, and improved access to more than 5300 miles of prime spawning and rearing tributaries and streams. Water would be cooler without the added heat of reservoirs and slower running water. A naturally flowing river would filter water more efficiently, creating better water quality. Columbia River salmon, as well as Snake River salmon, would benefit from the increased natural flows and significantly better water quality.

Survival of juveniles and adults would increase, since their migration timing would no longer be thrown off. Smoltification could occur naturally, uninterrupted by slack water reservoirs, dams, trucking or barging. Adults would expend less energy returning to their natal spawning grounds, which would result in more spawning adults.

Quicker migration times would expose juveniles to fewer predators. The population of pike minnows would be greatly reduced in the natural river, because the warm, slow moving water of the reservoirs would be gone. Further, there would be fewer predators in the natural habitat, and less time for the predators to prey in a faster flowing environment.

The effects of climate change would be reduced by a free flowing river, since natural flows and restored habitat would return the river to a natural temperature regime under which the salmon evolved. And quite significantly, a natural river has a greater than 30 times higher diversity of food that is available across the entire year, instead of just one or two months. The marine pump that transfers enormous amounts of rich nutrients from the ocean to the fresh water rivers and streams, a function of the returning adult salmon, would be restored. This would help revitalize the natural flora and fauna of the entire ecosystem, from healthier forest floors and trees, to the diversity of fish such as bull trout, lamprey and sturgeon, to the variety of insect populations, to the top predators such as bear, osprey, eagles, and the endangered food limited Chinook-eating Southern Resident orca population.

Further, there is increasing evidence that temperate reservoirs, such as the four behind the Snake River dams, are significant sources of methane gas, a greenhouse gas 34 times more potent than CO_2.[69] Methane accelerates climate change and further warms the reservoirs. Based on EPA research at a Corps lake in Ohio, the release of methane from temperate reservoirs subject to agricultural runoff makes these four pools significant contributors of greenhouse gases.

If doubts remain about whether the salmon and the ecosystem would be restored by dam removal, the Elwha River on Washington State's Olympic Peninsula is an excellent example of how rapidly a free flowing river can restore its watershed, and how rapidly salmon and other wildlife will return to an undammed river.

Conclusion
The four lower Snake River dams must be breached immediately to provide wild salmon runs on the Snake River the best chance to recover. The more than $600 million that the federal agencies spend annually on salmon recovery measures have not worked. There are no fixes for the four deadly slack water reservoirs behind the dams. The options have run out. Dam breaching makes both economic and ecological sense. It provides wild salmon the best opportunity to survive and recover, and will bring back to health the ecosystem that depends on this keystone species. It also provides the West Coast's iconic Chinook eating Southern Resident orcas the best chance at avoiding periodic starvation and extinction. The past decades have shown that throwing money at the dams in the hope that wild salmon will recover does not produce results. To continue to do so simply would be a waste of tax and rate payers' money.

[1] In preparing this document more than 100 hours were spent with federal and state fisheries biologists.

[2] See *e.g.*, *Nat'l Wildlife Fed'n v. Nat'l Marine Fisheries Serv.*, 839 F. Supp. 2d 1117, 1131 (D. Or. 2011) ("[T]here is ample evidence in the record that indicates that the operation of the FCRPS causes substantial harm to listed salmonids. . . . NOAA Fisheries acknowledges that the existence and operation of the dams accounts for most of the mortality of juveniles migrating through the FCRPS.")

[3] *Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye, 2014 Annual Report,* BPA Contract #19960200, November 2014, Chapter 4 and pp. xxvi, 79, 86, 104, 109, 112-118, http://www.fpc.org/documents/CSS/CSS_2014_Annual_Report.pdf; *Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye, Draft 2015 Annual Report,* BPA Contract #19960200, August 2015, pp. B-176, 84-85, 89, 92, 102, 105, 107, 110, 135-140, Appendix B, pp. B-1, B-22, B-25, B-26, http://www.fpc.org/documents/CSS/DRAFT_CSS_2015_Annual_Report.pdf. See also, Bonneville Power Administration, et al., *Federal Columbia River Power System Improvements and Operations under the Endangered Species Act –a Progress Report* (2013), pp. 2-3, 40-41, 51, https://www.salmonrecovery.gov/docs/FinalHydroSynthesisWithReview9-20-13.pdf.

[4] Columbia Basin Fish & Wildlife News Bulletin, *Snake River Sockeye Featured In American Fisheries Magazine; Natural Origin Fish Recovering?* November 21, 2014, http://www.cbbulletin.com/432662.aspx.

[5] Idaho Fish & Game, Sockeye Trap Returns, 10/16/15, http://fishandgame.idaho.gov/public/fish/?getPage=2.

[6] *Id.*

[7] *Id.*

[8] Columbia Basin Fish & Wildlife News Bulletin, *Snake River Sockeye: Lowest Return Since 2007, Captive Broodstock Program Increases Spawners*, September 11, 2015, https://www.cbbulletin.com/434944.aspx.

[9] *Idaho MU Recovery Plan—Draft Hatchery Discussions Snake River Spring/Summer Chinook Salmon and Steelhead*, p. 2, http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/Idaho/Revised ID MU docs as of 10-22-14/4.3_hatchery.pdf.

[10] See ODFW, USACE, Nez Perce, *Evaluating the Responses of Snake & Columbia River Basin Fall Chinook Salmon to Dam Passage Strategies & Experiences,* http://www.fws.gov/lsnakecomplan/Meetings/2013 Fall Chinook Symposium/Aug 7 Presentations/10-Rien Evaluating the Responses Dam Passage.pdf

[11] *Id.*; Smith, S.G., Marsh, T., Connor, W., *Draft Evaluating the Responses of Snake and Columbia River Basin Fall Chinook Salmon to Dam Passage Strategies and Experiences, 2006 and 2008* (December 2014), pp. iii, v, 8-9, 21, 28-30 (numbers released), 34, 36, 38, 41, 46, 50, 52, 56, 66.

[12] *Id.*

[13] See NOAA Fisheries, West Coast Region, *Proposed ESA Recovery Plan for Snake River Fall Chinook Salmon* (*Oncorhynchus tshawytscha)* October 2015, pp. 34-36, http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/proposed_snake_river_fall_chinook_recovery_plan.pdf.

[14] Wild Fish Conservancy Northwest, *Scientific Evidence on Adverse Effects of Steelhead Hatcheries,* http://wildfishconservancy.org/what-we-do/advocacy/steelhead-hatchery-reform/scientific-evidence-on-adverse-effects-of-steelhead-hatcheries.

[15] See Sando, R., et al., Letter to Stelle from Eight Scientists re Climate Change Impacts on Columbia Basin Salmon, 10/27/15, http://www.damsense.org/wp-content/uploads/2015/10/Scientists.to_.W.Stelle.climate.change.10.27.15.pdf.

[16] U.S. Army Corps of Engineers, Walla Walla District, *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement*, (2002), Appendix M, pp. M4 3-7, http://www.nww.usace.army.mil/portals/28/docs/environmental/lsrstudy/Appendix_M.pdf.

[17] Special Report on the Selection of Sites Lower Snake River, Corps of Engineers Portland District, March 14, 1947, pages 129 and 135.

[18] Port of Lewiston, Shipping Reports, http://portoflewiston.com/media-room/shipping-reports/; http://portoflewiston.com/wp-content/uploads/2015/09/AugX2015XShippingXreport.pdf .

[19] Jones, A., Rocky Mountain Econometrics, *Lower Snake River Dams Alternative Power Costs* (June 22, 2015), pp. 5-8, https://srkwcsi.files.wordpress.com/2015/06/2015-tony-jones-lsd-hydropower-replacement-costs.pdf. Even if the energy were not surplus, the Snake River dams produce less than 4% of the region's energy. Therefore, decommissioning the four dams leaves 96% of the region's energy in place.

[20] Oregon Dept. of Fish & Wildlife, *Oregon Native Fish Status Report – Volume II,* p. 138, http://www.dfw.state.or.us/fish/onfsr/docs/final/02-fall-chinook/fc-methods-snake.pdf; U.S. Fish and Wildlife Service (USFWS), 2009, *Dworshak, Kooskia, and Hagerman National Fish Hatcheries: Assessments and Recommendations Appendix B: Briefing Document; Summary of Background Information. Final Report, June 2009,* Hatchery Review Team, Pacific Region. U.S. Fish and Wildlife Service, Portland, Oregon, pp. 10-11, http://www.fws.gov/pacific/fisheries/hatcheryreview/Reports/snakeriver/LowerSnakeNFHReview.AppendixB.June2009.FINAL.pdf.

[21] See Giles, D.A., et al., *Letter to the Honorable Jo-Ellen Darcy, Recovering Federally Endangered Killer Whales by Breaching the Four Lower Snake River Dams*, 1/14/15, https://srkwcsi.files.wordpress.com/2015/10/lettertodarcy.pdf.

[22] In addition, the Army Corps of Engineers is required to review federal dam operations when advisable, to improve the quality of the environment in the overall public interest. 33 U.S.C. § 549a.

[23] U.S. Army Corps of Engineers, Walla Walla District, *Lower Snake River Juvenile Salmon Migration Feasibility Report* (2002), http://www.nww.usace.army.mil/Library/2002LSRStudy.aspx.

[24] Budy, P., *Analytical Approaches to Assessing Recovery Options for Snake River Chinook Salmon* (2001), p. 4, UTCFWRU 2001(1): 1-86, http://www.fws.gov/columbiariver/publications/recopt.pdf; *Lower Snake River Juvenile Salmon Migration Feasibility Report* (2002), *Appendix A, Anadromous Fish Modeling,* p. A ES-8, http://www.nww.usace.army.mil/portals/28/docs/environmental/lsrstudy/Appendix_A.pdf.

[25] Budy, P., *Analytical Approaches to Assessing Recovery Options for Snake River Chinook Salmon* (2001), *supra*, *Id.*, pp. 5-6.

[26] *Id.*, p. 6.

[27] *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement*, (2002), Appendix M, *supra*, pp. M ES-13. See also *Id.*, M ES-9 through ES-14.

[28] See *e.g.*, articles confirming non-breaching choice prior to official announcement in 2002, *Federal Agencies Propose Comprehensive Salmon Recovery Strategy for Pacific Northwest; Call on States, Tribes to Join in Restoration Effort*, 2000, http://www.noaanews.noaa.gov/stories/s467.htm; *Conservation of Columbia Basin Fish, Final Basinwide Salmon Recovery Strategy*, Vol. 1, (2000), pp. 2-3, http://www.salmonrecovery.gov/Files/BiologicalOpinions/2000/2000_Final_Strategy_Vol_1.pdf.

[29] See *e.g.,* BioScience, Whitelaw, E., MacMullan, E., *A Framework for Estimating the Costs and Benefits of Dam Removal* (2002), http://bioscience.oxfordjournals.org/content/52/8/724.full; Waddell, J., *The Costs of Keeping the Four Lower Snake River Dams: A Reevaluation of the Lower Snake River Feasibility Report*, 7/28/15, http://www.damsense.org/wp-content/uploads/2015/07/Cost-LSR-Dams-1-1-2015F-2-vers-7-30-15.pdf.

[30] *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement*, (2002), Appendix M, *supra*, pp. M ES-1 & ES-2, http://www.nww.usace.army.mil/portals/28/docs/environmental/lsrstudy/Appendix_M.pdf.

[31] *Conservation of Columbia Basin Fish, Final Basinwide Salmon Recovery Strategy*, Vol. 3, (2000), p. 20, http://permanent.access.gpo.gov/lps57088/d3/Final_Strategy_Vol_3.pdf.

[32] *Id.*

[33] *Lower Snake River Juvenile Salmon Migration Feasibility Report* (2002), *supra*, *Appendix A, Anadromous Fish Modeling,* p. A ES-8, "It will require anywhere from 2 to 10 years for these studies to provide information about the feasibility of achieving demographic improvements through different management actions." http://www.nww.usace.army.mil/portals/28/docs/environmental/lsrstudy/Appendix_A.pdf.

[35] *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement*, (2002), Appendix M, *supra,* M ES-1.

[36] NOAA Fisheries, *Invasive Species and Salmon: Interactions in the Pacific Northwest* (2014), http://www.nmfs.noaa.gov/stories/2014/07/7_21_14invasive_species_and_salmon.html.

[37] While steelhead have the ability to migrate multiple times before dying, the potential for them to make a round trip through the dams more than once is assumed to be near zero. *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement, supra,* fn. 5, at M4-7.

[38] See *e.g.*, NOAA Fisheries, *Memorandum from Zabel to Wieting, Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2014*

11/4/14, http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/2014_memo_-_columbia_river_outmigration_estimates.pdf.

[39] *Federal Columbia River Power System Improvements and Operations under the Endangered Species Act – a Progress Report* (2013), *supra,* pp. 2-3, 40-41, 51, https://www.salmonrecovery.gov/docs/FinalHydroSynthesisWithReview9-20-13.pdf; https://www.nwcouncil.org.

[40] *Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye, 2014 Annual Report,* BPA Contract #19960200, November 2014, p. 79, http://www.fpc.org/documents/CSS/CSS_2014_Annual_Report.pdf.

[41] *Id.*

[42] *Id.,* p. xxvi & Chapter 4.

[43] *Id.* at 104.

[44] Schaller, H., U S Fish and Wildlife Service, Petrosky, C., Idaho Department of Fish and Game American Fisheries Society Meeting, August 2015, *Relationship of smolt-to-adult return rates to productivity and implications for population recovery*, p. 9, http://www.fws.gov/columbiariver/2015_AFS_Presentations/AFS SAR v productivity schaller petrosky 08_14_15.pdf.

[45] Much of the juvenile loss occurs in the Lower Snake River hydrosystem. In 2015 the mortality rate for wild stock alone was 49%. For hatchery and wild Chinook salmon combined, the mortality rate through the Snake River dams was 32%. Further evidence that juvenile outmigration mortality through the Snake River dams has not decreased over time is NOAA Fisheries' acknowledgment in 2013 that, "Chinook survival through the hydropower system has remained relatively stable since 1999 with the exception of lower estimates in 2001 and 2004." The true juvenile mortality rates are much higher than the Corps, BPA and lobbyist groups' oft-repeated assertions of no more than 1%-5% mortality per dam.

[46] NOAA Memorandum, Zabel, R., *Preliminary Survival Estimates for the Spring-migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs*, 2015, 9/10/15, p. 2, http://www.nwd-wc.usace.army.mil/tmt/agendas/2015/1021_Preliminary_Survival_Estimates_Memo_2015_1021.pdf.

[47] *Id.,* pp. 2-4.

[48] *Id.,* pp. 3, 5.

[49] *Id.,* p. 5.

[50] *Id.,* p. 3.

[51] *Id.,* p. 4.

[52] Oregon Dept. of Fish & Wildlife, *Oregon Native Fish Status Report – Volume II, supra,* p. 138; *Dworshak, Kooskia, and Hagerman National Fish Hatcheries: Assessments and Recommendations Appendix B: Briefing Document; Summary of Background Information. Final Report, June 2009, supra,* pp. 10-11. See also, *Lower Snake River Juvenile Salmon Migration Feasibility Report* (2002), *supra, Appendix A, Anadromous Fish Modeling,* p. A ES-6, "breaching is expected to increase the carrying capacity (available habitat) for fall chinook salmon by more than 70 percent."

[53] Miracle, A., et al., *Spillway-Induced Salmon Head Injury Triggers the Generation of Brain αII-Spectrin Breakdown Product Biomarkers Similar to Mammalian Traumatic Brain Injury*, (2009), http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0004491.

[54] See DeHart, M., Fish Passage Center, Memorandum, *Requested Data Summaries and Actions regarding Sockeye Adult Fish Passage and Water Temperature Issues in the Columbia and Snake Rivers*, 10/28/15, pp. 51-52, http://www.fpc.org/documents/memos/159-15.pdf.

[55] Fish Passage Center, Memorandum, *supra*, pp.2, 7, 11-13, 20.

[56] Fish Passage Center, Memorandum, *supra*, pp. 1-2, "Hydrosystem development has had a significant effect on temperature in the mainstem Columbia and Snake rivers. By slowing water flow and increasing surface area for solar radiation, dams caused increased water temperatures in the reservoirs." "Significant long-term actions to address these temperature issues are necessary for the continued survival of salmon populations."

[57] Fish Passage Center, Memorandum, *supra*, p. 5; *Federal Agencies Break the Law: Dams Create Lethally Hot Water and Fish Kills*, 7/31/15, p. 2, http://columbiariverkeeper.org/wp-

content/uploads/2015/07/2015.07.31-temp-dams-press-release-final.pdf. See also The News Tribune, *EPA Leans Towards Dam Breaching*, 2000, http://news.fwee.org/?p=2159.

58 *Invasive Species and Salmon: Interactions in the Pacific Northwest, supra*.

59 *Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye, 2014 Annual Report, supra,* Chapter 4 and pp. xxvi, 79, 86, 104, 109, 112-118; *Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye, Draft 2015 Annual Report, supra*, pp. B-176, 84-85, 89, 92, 102, 105, 107, 110, 135-140, Appendix B, pp. B-1, B-22, B-25, B-26.

60 *Conservation of Columbia Basin Fish, Final Basinwide Salmon Recovery Strategy*, *supra*, pp. 5-6.

61 *Nat'l Wildlife Fed'n v. Nat'l Marine Fisheries Serv.*, *supra*, 839 F. Supp. 2d at 1125 n. 3.

62 *Idaho MU Recovery Plan—Draft Hatchery Discussions Snake River Spring/Summer Chinook Salmon and Steelhead*, *supra,* p. 2.

63 *Id*., p. 2.

64 *Id*., pp. 2-4.

65 *Id*.

66 *Id.*, p. 19.

67 *Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye, 2014 Annual Report, supra,* Chapter 4, p. 80.

68 *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement*, (2002), Appendix M, *supra,* pp. M ES-9 through ES-11.

69 See, e.g., Beaulieu, J., et al., Environmental Science & Technology, *High Methane Emissions from a Midlatitude Reservoir Draining an Agricultural Watershed* (2014), http://pubs.acs.org/doi/pdf/10.1021/es501871g.