An Assessment of Barriers to Migration of Steelhead Trout in the Lower Snake River, USA

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Introduction:

Although the northwest region of the United States of America has long been noted for its innate natural beauty and abundant wildlife, it is quickly becoming a breeding ground for ecological and environmental concern. Where natural forests used to be there are now clear-cuts, where free-flowing water ran there are now stagnant reservoirs, and where steelhead trout used to migrate by the million, there are now only several thousand each year that survive the journey to the ocean. The Columbia River's natural beauty and potential is slowly being diminished by human influences to the detriment of the environment and to our society as a whole.

The Snake River, which runs through Idaho and eastern Washington, is the largest tributary of the Columbia River, and has historically been the source of a large percentage of the Northwest's anadromous salmonid population, which migrates annually down the Columbia to the Pacific Ocean (Keefer 930). In the past, about 45% of Columbia chinook salmon was originally from the Snake River, but its current fish runs are significantly smaller than ever before (Gregory, Li, and Li 720). In this paper, I analyze some of the major causes of decline of steelhead trout populations (the Snake River steelhead are now listed as threatened under the Endangered Species Act), discuss current mitigation strategies, and explore the controversy circulating around the idea of breaching the Snake River's four lowest dams: the Lower Granite, Little Goose, Lower Monumental and Ice Harbor dams (shown in Figure 1, Gregory, Li, and Li 721) (Evans et al. 1089).

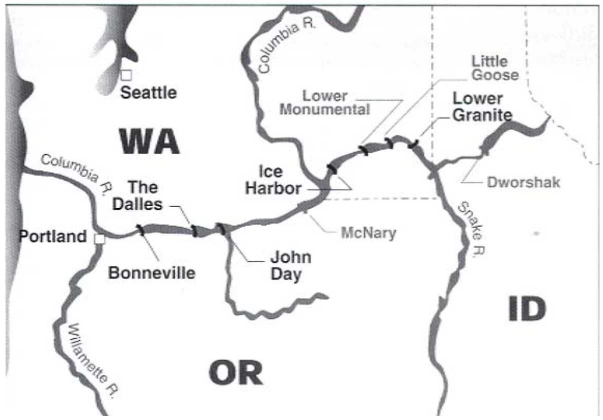

Fig. 1: The confluence of the Columbia and Snake rivers and the system's eight large dams

History:

Although many studies have been done analyzing salmon in the Columbia and Snake rivers, the variety of literature on steelhead trout (*Oncorhynchus mykiss*) is limited. This fact is, at first glance, an acceptable statement, given the history of Native American cultural traditions and the public's familiarity. The Columbia River is known for its historical runs of between 10 and 16 million fish, and public awareness of decreasing survival rates is growing (Northwest Planning Power Council). The reality becomes slightly less intuitive, however, when one considers the potential for restoration held by iteroparous fish such as steelhead. Most anadromous fish, including chinook, coho, chum, pink and sockeye salmon are not iteroparous, meaning that they die after spawning only once. Steelhead trout, however, usually survive 2-4 migration cycles and spawn multiple times; so while aiding one salmon smolt in its migration downstream may result in only one future salmon spawning, saving the life of one steelhead kelt (postspawner) may result in several spawning cycles. Environmentalists must take caution, however, to avoid implementing methods that would help the kelts while further endangering the smolts and juveniles.

Current Mitigation Strategies:

Many of the protection policies in place today do not distinguish between salmon and steelhead smolts, thus a byproduct of mitigation efforts for salmon is increased steelhead smolt protection. However, little research has been done to increase protection efforts for both downstream- and upstream-migrating kelts, which by necessity require different travel aids due to larger sizes and varying swimming capabilities (Wertheimer 854-5 and 862).

Turbines and Spillways:

In theory, migratory fish are provided several options of dam passage, depending on structures and practices in place at the individual dam. Turbine passage and spillways are two of the most frequently used practices, although not very efficient. Turbine passage is a leading cause of fish mortality, and although it is certainly cheap, economically efficient, and favorable to dam managers and energy companies, it is not a remotely acceptable solution to the steelhead migration problems (Johnson et al. 138). "Guidance efficiency for turbine intake screens varies by species, time of year, and location, and may result in different size selectivity" (Johnson 139).

Spillways successfully divert about 90 percent of fish from turbine passages when the spill gates are open (Wertheimer 853). This number does not, however, communicate any mortality that occurs further downstream as a result from shock from the plunge or from increased levels of dissolved gas in the water, which cause the trout to experience a fishy equivalent of the bends (Gregory, Li, and Li 716). Further, spillways are economically inefficient because they direct the water around the turbines, not through it, and thus expend a great deal of water that could be used for hydropower in the turbines (Johnson 139). The huge opportunity cost of all the lost potential financial gains is generally sufficient persuasion to argue that opening spillways to save select fish will not be a satisfactory practice in the long run.

Barge Transportation:

One common practice is to gather the fish at one of four collection facilities located along the Snake and Columbia rivers and either return them to the river just downstream of the dam in question or transport them around the remaining dams downstream (Wagner et al. 259). Fish transported around the entire hydrosystem had a survival rate that was 25-50 percent higher than that of fish that passed through them (Gregory, Li, and Li 721). Barge transportation is not a likely means to restore the fish populations to their historical size, however, since is has been a common practice for about 25 years and steelhead numbers continue to decline (Wagner et al. 260). It is also fairly expensive and inefficient.

A "Global Landscape" Hatchery Perspective:

Although most hatcheries focus on various types of salmon, there are steelhead production facilities. Competition between hatchery and wild fish is a source of concern because it results in decreased resources for the wild fish, and downstream migrating steelhead who have traveled hundreds of miles to finally reach a hatchery facility on their way to the ocean are no match for rested, stronger hatchery fish who compete fiercely for food resources and spawning grounds. One improvement to this reality (it cannot in good faith be called a solution) is a global management perspective for hatcheries. Instead of acting as isolated production facilities, the hatcheries must integrate themselves into the surrounding ecosystem, analyzing effects of hatchery fish on the wildlife and also considering the factors that affect the fish (Williams et al.). This "outside the fence" perspective will result in increased harmony between wild and hatchery fish, will contribute to the greater health of both types of fish, and produce a more effective management strategy for hatchery facilities (Williams et al.).

Potential Mitigation Strategies:

Despite the intentions of current practices used to aid the fish on their migratory journeys, numbers continue to dwindle, and mortality rates are high enough to prevent a self-sustaining (much less restorable) steelhead trout population from gaining a strong foothold in the Snake River. Several mitigation theories are currently being tested in practice and hold great potential for the future of wild trout runs in the Northwest.

Surface Flow Bypass:

Several varieties of surface flow bypass structures have been tested at the Bonneville and Lower Granite dams and are currently being developed further. Meant to reroute fish away from turbine intakes and give them safe passage around the dams, these devices are successful in rerouting some of the fish in the upper water column, although the structures themselves are only temporary (Johnson 139). Gary E. Johnson and his associates document a study done over a five-year period from 1996 to 2000 on the first prototype, a surface bypass and collector (SBC). They find that SBCs are more efficient and effective (with efficiency measured in terms of the proportion of fish using the SBC out of the total number passing through the dam, and effectiveness measured as a ratio of the proportion of fish using the SBC and the proportion of water passing through the structure) than either turbine or spill passage (147). Further, they assess the validity of surface flow bypass structures as a realistic mitigation method, noting that data showed that 50 percent of fish passing through the dam used the SBC while only 10 percent of the water passing through the dam was expelled through the structure, and conclude that it is in fact a potentially viable solution to high fish mortality rates (147). Because the Lower Granite Dam resembles the other three lower Snake River dams, they conclude that SBCs could be further developed to fit specific characteristics of each dam without diminishing the integrity or success of the structure (149).

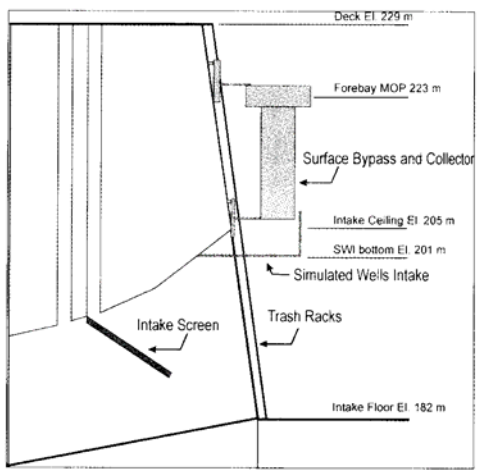

FIGURE 2.—Sectional view of the powerhouse at Lower Granite Dam, showing the surface bypass and collector (SBC), turbine intake occlusion (simulated Wells intake [SWI]), and an intake screen.

Dam Deconstruction Analysis:

The most encompassing solution to the general decline of river health, dam deconstruction, is also the most controversial. The suggestion has been put forth, with the growing support of ecologists and biologists nationwide, to decommission the lower four Snake River dams. Opponents are mostly concerned with the economic impacts in the Northwest, while proponents cite data showing that a return to natural river conditions has a higher potential than any to restore, or at least sustain, current fish runs. Seventy-five thousand dams have been built in the United States, and only abut 500 of the smaller dams have been deconstructed (Gregory, Li, and Li 713). To date, very little research has been done on the effects of decommissioning dams greater than 30m high, and so a large amount of uncertainty exists with regard to whether long-term impacts will truly be beneficial to the environment (and acceptable to the economy) or whether routine dam maintenance and technological improvements are more appropriate.

Dam Breaching Cons:

The numerous uncertainties about dam breaching that exist make support for the idea difficult to generate. Geographical problems, water control issues, and economic questions swirl around the idea in an unending pattern. Sediments build up behind dams, creating deep deposits of sediments and minerals. As time passes, the minerals are buried underneath new layers of fresh sediment, and by breaching the dam wall, the barrier to sediment travel will be removed (Gregory 714). Ecologists are not confident about types and amounts of possible minerals and toxins buried underneath sediment piles, and removing the wall would make deposits prone to frequent flood erosion, releasing the unstable walls of buried sediment into the water where they would come into direct contact with migrating salmonids swimming by (Gregory, Li, and Li 714).

Other issues include effects on the food web upstream, where steelhead may lose some of their spawning ground due to increased numbers of anadromous species migrating further upstream than before (Gregory, Li, and Li 717). While crowding in the river is not a realistic issue yet, increased population in spawning beds may result in greater competition (and predation) in those areas. Recently,

> The US National Marine Fisheries Service estimated that anadromous salmon stocks have a 55%-100% probability of extinction over the next 100 years, and concluded that the removal of the dams would not reduce the risk of extinction under current conditions. (*conceptual)

This statement is consistent when one considers that while breaching the four lowest Snake River dams would give steelhead (and any other anadromous fish that spawn in tributaries of the Snake River) the ability to migrate upstream and downstream without such massive obstacles, it would not help the eight listed stocks in the Columbia River.

The most immediately obvious negative impacts of dam decommissioning are economic ones. Although estimates for costs of decommissioning any large dam are high, they dwindle when juxtaposed with price tags for the necessary maintenance and repair that will be needed once the dams have been in place for 50 years (which will occur in the next two decades for all of the lower four Snake River dams). Harder to justify for environmentalists is the loss of jobs that will occur when dams are no longer in operation and barge transportation is no longer necessary. Additionally, utility prices would probably increase when less energy from hydropower is available. Irrigation and flood issues may impact land prices in select areas, and the town of Lewiston, Idaho would no longer be available as a seaport, since the free-flowing waters would be less navigable (Whitelaw and Macmullan 726). Some detractors also argue that recreational attractions in the Northwest would be severely impacted by the lack of water control.

Dam Breaching Pros:

Despite the many reasons to argue against dam deconstruction as a potential solution to the problems of declining anadromous fish numbers, its existence, by virtue of the all-encompassing nature of dams, cannot be ignored in the debate about Columbia

River basin restoration. It is estimated that survival rates for fish passing through one dam are about 90 percent, which means that after four dams steelhead survival rates are down to about 66 percent, and after all eight dams in the Columbia-Snake River system, only about 43 percent of the migrating fish survive, despite the protection measures (Gregory, Li, and Li 718). Economically speaking, the job loss would probably not hit the local economy as hard as predicted:

> For the counties in southeastern Washington, northeastern Oregon, and central Idaho near the lower Snake River with counties the Corps treated as the relevant local economy— [in 2000] the Corps estimated a net loss of 711 long-term jobs [after dam removal], less than 0.3% of the employment in these 15 counties (Whitelaw and Macmullan 729).

With regard to recreational activities around the Snake River, they could actually increase in popularity, with tourists drawn to the natural beauty and wild waters. The rights of Native American tribes to traditional sites and fishing grounds would be restored and treaties upheld, impacting relations between the tribes and the US government in a positive way (725).

Reviewing the construction of the four lower Snake River dams from an environmental point of view, one can see that they completely changed the surrounding ecosystem, to the detriment of all the wildlife in the northwest. One of the principal functions of a dam is flood control; dams dampen effects of peak flows and consequently reduce benefits of flooding and stream complexity, while increasing the number of reservoirs (Gregory, Li, and Li 714). This results in a loss of spawning ground and habitat. For example, after damming and developing the Willamette River, 50 percent of its channel complexity was lost as a consequence of channel construction and flood control (Gregory, Li, and Li 715). In the Columbia, steelhead have lost access to about

55 percent of the total area they could reach before dam implementation (Gregory, Li, and Li 718). Breaching the four Snake River dams would restore natural channels along the Snake River and allow fish to utilize newly accessible areas for spawning and rearing grounds.

Time spent by fish in these reservoirs is especially critical, because water levels and temperatures in the reservoirs increase while flow rates decrease (Gregory, Li, and Li 716). These conditions are prime for native predators such as the pike-minnow or avian predators, which prey upon weakened salmonids trapped in the reservoirs (Gregory, Li, and Li 717). Sediment build-up results in increased mineral levels, and water quality in general is compromised. The existence of inter-species relationships is altered when conditions allow new or different species to thrive, and thus food webs are changed (Brusven et al. 373). Especially "in the Columbia River, the food web has been greatly altered, and the effect of introduced piscivores appears to have increased mortality in an additive fashion" (Gregory, Li, and Li 717). The changes that have occurred are not in the best interests of the fish populations.

Summary:

Although there are certainly other factors involved, such as over-harvesting, loss of habitat and bad ocean conditions, it cannot be denied that dams on the Snake River play a large role in migrations of steelhead smolts and kelts, and also on all anadromous salmonids in the region. While there are many unexplored and unresolved concerns about tearing down the Lower Granite, Little Goose, Lower Monumental and Ice Harbor dams, the suggestion continues to stand above all others in terms of total change enacted, and the overall benefits to the region. Regardless of the outcome of the dam debate, we must keep in mind that the health and prosperity of populations of fish in the Snake River have a direct impact on the health and prosperity of those in the Columbia River Basin, and will play an incredibly vital role in any recovery effort that is made (Blumm et al. 999). Until this option can be fully explored, surface flow bypass structures promise to be fairly efficient and effective in rerouting fish around the dams. Ecologists must also continue to research and develop mitigation strategies for kelts migrating up and downstream, since they potentially hold the promise of several more spawning cycles and are an important source of steelhead regeneration.

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