Snake River Spring and Summer Chinook Salmon—The Choice for Recovery

By Douglas J. Nemeth and Russell B. Kiefer

ABSTRACT

The Snake River was once the most productive tributary of one of the greatest salmon producing river systems in the world, the Columbia River. Four dams completed on the lower Columbia River and Snake River from 1938 to 1961 resulted in decreased, but still robust adult returns of spring and summer chinook salmon (*Onchorhynchus tshawytscha*) to the Snake River basin. Four additional dams completed from 1968 to 1975 resulted in a systematic decrease in smolt-to-adult return rate that has yet to be reversed. Snake River spring and summer chinook salmon were listed as threatened under the U.S. Endangered Species Act in 1992. Recovery efforts to date have been based on a mechanistic foundation (i.e., based on engineering and technology) and have failed to achieve recovery. Comprehensive investigations into the plight of Snake River spring and summer chinook salmon concluded that restoring some level of pre-dam ecosystem function, rather than continuing to rely on mechanistic actions, has a high probability of achieving recovery. The choice to restore some level of pre-dam ecosystem function will require a significant change in management of the Columbia and Snake rivers.

The Columbia River basin was once one of the greatest salmon producers in the world (Schalk 1986). As Meriwether Lewis traveled through the basin in 1805, he wrote, "The multitude of this fish (salmon) are almost inconceivable" (Lewis 1814:426). Within the Columbia basin, the Snake River drainage was once the most significant in terms of salmon production. After completion of Bonneville Dam (1938), McNary Dam (1953), The Dalles Dam (1957), and Ice Harbor Dam (1961) (Figure 1), spring and summer chinook salmon returns to the Snake River basin declined but still supported extensive sport and tribal fisheries (Keating 1969; Keating et al. 1971; WDFW and ODFW 1997). The addition of Lower Monumental Dam (1969), Little Goose Dam (1970), and Lower Granite Dam (1975) on the lower Snake River, and the John Day Dam (1968) on the Columbia River (Figure 1), dramatically altered the ecosystem through which Snake River spring and summer chinook salmon migrated to reach the Pacific Ocean. As a result, adult returns of Snake River spring and summer chinook salmon began a decline that has not yet been reversed.

The decline of adult returns was a manifestation of decreased *smolt-to-adult return rates* (SARs; e.g., the total number of adults returning from a given brood divided by the number of emigrating smolts produced by that brood). Methods applied to reverse the decline in smolt-to-adult survival were mechanistic in nature (i.e., based on engineering and technology) and addressed direct mortality caused by turbines, predators, etc. (Park 1985). The primary tool used to achieve salmon recovery was smolt transportation. Smolt transportation entailed collecting smolts at various dams, loading them onto trucks or barges, and transporting them down the Columbia River for release below the lower-most dam (Park 1985). The premise was to improve survival by avoiding direct mortality caused by the dams and their associated reservoirs. Researchers concluded that the program was a viable recovery tool (Park 1985). However, independent reviews of smolt transportation research indicated serious experimental design flaws affecting the verity of the conclusions (Mundy et al. 1994; Ward et al. 1997; F. Olney, Anadromous Fish Review Technical Committee, U.S. Fish and Wildlife Service, Region 1, pers. comm.).

Recovery efforts to date not only have failed to recover Snake River spring and summer chinook salmon, they have not even halted the decline. Examination of potential causes of mortality beyond the dams in the Columbia and Snake rivers, and comparisons between Snake River stocks and similar stocks occurring below the Snake River dams, indicate that the system of dams on the lower Snake and Columbia rivers continues to be the primary factor limiting SARs and recovery (Schaller et al. 1999).

The foundation used to restore salmon in the Columbia and Snake River basins has been based on the use of mechanistic solutions (ISG

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1999). Two comprehensive reviews of Snake River spring and summer chinook salmon have indicated that a foundation for salmon recovery based on restoring some level of pre-dam ecosystem function in the lower Snake River and Columbia River is most likely to succeed (Marmorek et al. 1998; ISG 1999). The choice to adopt this foundation for recovery will require a fundamental change in management of the Snake and Columbia rivers.

This paper aims to distill the issues pertinent to the demise of Snake River spring and summer chinook salmon, recovery measures taken to date, and new analyses that prescribe recovery actions. The paper proceeds chronologically, beginning with past resources of the Snake River basin, the consequences of additional dam building on salmon returns and survival, mitigation efforts and their effectiveness, and needed actions to achieve recovery. We focus on Snake River spring and summer chinook salmon. However, in some instances it was not possible, or appropriate, to separate other Snake River anadromous fish species or the Snake River from the Columbia River when providing historic perspective or information. We bring this to the reader's attention in all such cases.

Past resources

The Columbia River is the fourth largest river in North America, draining more than 260,000 square miles, including land in seven U.S. states and one Canadian province (CBFWA 1996; Figure 1). During the 1800s, at least 16 million salmon and steelhead (*Oncorhynchus mykiss*) returned to the basin annually, making it one of the most productive salmon rivers in the world (Schalk 1986). The Snake River basin drains approximately 40% of the Columbia basin and historically has produced more salmon and steelhead than any other tributary (Schmitten et al. 1995). Within this basin, the Salmon River once contributed approximately 40% of the spring-run and 45% of the summer-run chinook salmon (*Oncorhynchus tshawytscha*) returning to the entire Columbia River basin (CBFWA 1996).

From 1962 to 1967, the five years immediately following completion of the first lower Snake River dams (Ice Harbor), approximately 45,000 adult spring and summer chinook salmon entered the Snake River basin (WDFW and ODFW 1997), and SARs averaged 4% (Raymond 1988). Recreational and tribal fisheries for chinook salmon occurred throughout the Snake River basin, allowing fishing opportunities ranging from urban to wilderness (Keating 1969; Keating et al. 1971). From the mid-1950s through the 1960s, an average 16,000 wild chinook salmon were harvested annually in Idaho (Keating 1969; Keating et al. 1971).

However, there was interest in using the Columbia and Snake rivers for more than salmon production. Farmers and business professionals had been interested in water navigation to transport goods from Lewiston, Idaho, to western Oregon and Washington since the 1800s as a cheaper alternative to the railroads (Petersen 1995), but the cost incurred by the government for such an undertaking was not justified by the benefits to private industry (Schley 1938). Apparently, Congress did not authorize construction of the lower Snake River dams until political tensions during the Cold War in 1945 created concern about providing cheap electricity to the now-decommissioned Hanford Nuclear Plant (Petersen 1995).

As these dams came nearer to becoming a reality, state and federal agencies became more vocal regarding possible impacts to fisheries resources. As noted by the U.S. Fish and Wildlife Service (USFWS), "The Lower Snake River dams collectively present the greatest threat to the maintenance of the Columbia River salmon populations of any project heretofore constructed or authorized" (USFWS 1952:2,909), but construction proceeded nonetheless.

Consequences

After the dams on the lower Snake River and the John Day Dam on the Columbia River were completed (1961 to 1975), 600 miles of

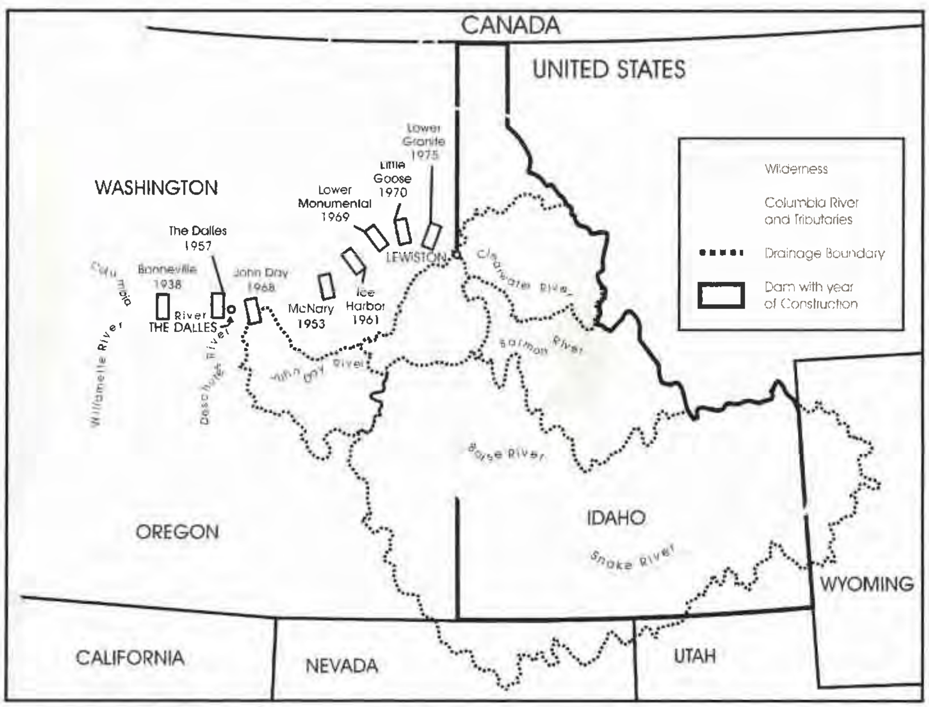

Figure 1. A map of the Columbia River and Snake River basin showing dams and dates of completion.

free-flowing river from Lewiston, Idaho, to the mouth of the Columbia River changed to slack water (Schmitten et al. 1995). The effect on Snake River anadromous fish was dramatic, immediate, and noticed. In 1974, even before Lower Granite Dam was operational, the *Lewiston Morning Tribune* wrote in a 3 October editorial about the diminished returns of salmon: "It seems to us another case of pushing a plan for economic gain without finding out first how much it was going to cost. Together with most of our fellow citizens, we now fear that those lower Snake River dams for which we campaigned so hard have cost us too much." During the five years immediately after completion of Lower Granite Dam in 1975, the return of wild spring and summer chinook salmon adults declined to approximately 27,000 fish annually, a 40% decrease from 1962–1966 averages (WDFW and ODFW 1997).

Smolt-to-adult return rate decreased systematically with the construction of each new dam. After completion of Lower Monumental Dam in 1969, the SAR decreased from 4% to 3.5% (Ebel 1977). In 1970, when Little Goose Dam was completed, SAR declined to 3.2%, and by 1972 the SAR dropped to 0.8% (Ebel 1977), and Lower Granite Dam was not yet completed.

Mitigation

Since the fear expressed by the *Lewiston Morning Tribune* was shared among agencies, fishers, and others, scientists and engineers began to search for ways to mitigate the effects of these new dams. Juvenile bypass systems were retrofitted to the dams, but the design of the dams limited the benefits to fish. Flow augmentation to help speed migrants to the sea was planned but rarely implemented (CBFWA 1996). Although spillway flow deflectors were installed to decrease the extent of nitrogen saturation, spill was not regularly used to directly benefit fish because it meant production of electricity was not being maximized (Blumm and Simrin 1991; Lee 1993). When taken, these actions likely improved smolt survival to some degree, but smolt transportation was at the core of the plan to recover wild Snake River spring and summer chinook salmon.

Smolt transportation research began in the Snake River basin in 1968. Researchers sought to determine the feasibility of eliminating direct mortality due to turbines, predators, gas supersaturation, and migration delay caused by the four lower Snake River dams (Park 1985). Research centered primarily on two aspects: (1) the relative survival of known transported smolts (the treatment) to the control group and (2) the ability of fish transported as smolts to successfully return as adults to the uppermost dam (Park 1985).

To compare the relative survival of transported smolts to the control group, a transport:control ratio (T:C) was used. To arrive at this ratio, smolts were collected at one or more of the following dams—Lower Granite, Little Goose, Lower Monumental, and McNary (Figure 1)—and split into two groups. Fish destined for barging received one mark, while the control group received a different mark and was eventually returned to the reservoir, although sometimes after being trucked upstream. When the adults returned, the fish with each mark were tallied, and the T:C ratio was calculated and tested for a significant difference. From 1968 through 1980, transported spring chinook salmon returned in significantly higher numbers in only 8 of 18 tests (returns of transported steelhead smolts were markedly better) (Park 1985). Researchers also concluded that chinook salmon homing ability was not significantly impaired (Park 1985). National Marine Fisheries Service (NMFS) researchers believed the smolt transportation program could be a viable enhancement tool for restoring Columbia River salmon and steelhead (Park 1985), and in 1981, mass transportation of smolts, which began in 1976, became an "operational program" (Park 1985). The anticipated success of the transportation program, together with other engineering changes and hatchery production, was so high that one researcher proclaimed, "...it seems possible that we can establish adult runs of both steelhead trout and salmon in far greater numbers than existed before" (Ebel 1977:39).

However, some scientists eventually raised concerns about the design of the experiments used to evaluate smolt transportation and the veracity of the conclusions drawn by the researchers (Mundy et al. 1994; Ward et al. 1997; F. Olney, Anadromous Fish Review Technical Committee, USFWS, Region 1, pers. comm.). One of the most troubling problems related to the control group. The control group should have represented a migrant that traveled under its own volition through the dams and reservoirs without experiencing any of the procedures undergone by the transported group such as collection, marking, or transportation. Instead, all control groups were collected and marked, and some were even eventually transported by truck or barge. The efficacy of smolt transportation then was measured by the ratio of adults returning from the transported group versus the control group, even though the ratio did not reflect survival of a true control—a never-collected, never-handled, and untransported migrant. Rather, the ratio compared survival of collected, marked, and transported individuals to a group that was always collected and marked, and sometimes also transported. Additionally, whether one of these groups outperformed the other was not necessarily relevant to the question regarding the utility of smolt transportation to recover Snake River spring and summer chinook salmon. Under conditions of extremely low survival, extinction could occur even though a positive and significant T:C ratio was achieved (Mundy et al. 1994). The relevant question was how to improve absolute survival, measured to the spawning grounds (Mundy et al. 1994).

Results

Snake River spring and summer chinook salmon were listed as threatened under the federal Endangered Species Act in 1992 (NMFS 1992). The escapement goal of 25,000 wild or natural adult spring chinook salmon over Lower Granite Dam and into the Snake River basin has not been met for 19 consecutive years, and the 1995 return year was the lowest in history (WDFW and ODFW 1997). The minimum escapement goal for summer chinook salmon over Bonneville Dam has not been met in 29 years (WDFW and ODFW 1997).

Smolt-to-adult return rates have not rebounded with implementation of the smolt transportation program (Figure 2) and are generally within the same range of those predicted by NMFS without the alleged benefit of the smolt transportation program (Collins et al. 1975). The median SAR to recover Snake River spring and summer chinook salmon (4%) (Marmorek and Peters 1996) is about 17 times higher than the mean SAR achieved by collection and transportation during the 1989–1995 smolt emigration years (mean 0.23; range: 0.05–0.44) (Figure 2; Appendix).

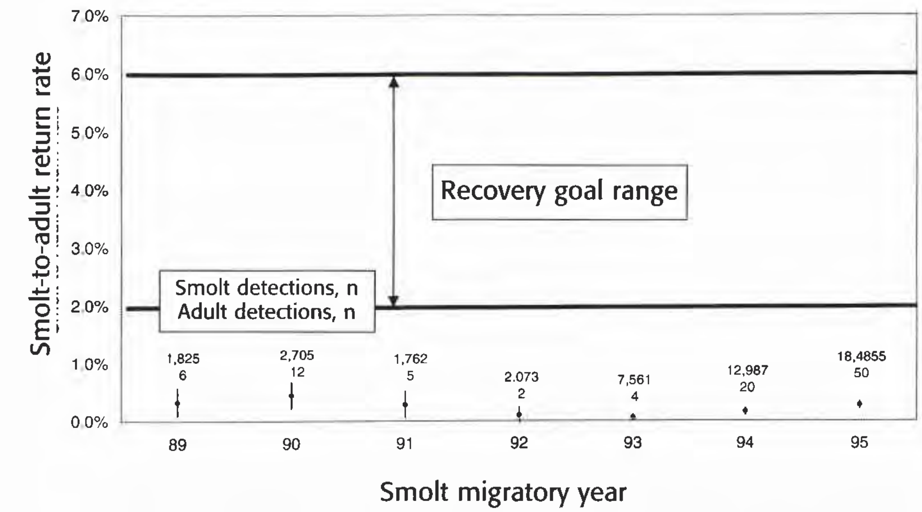

Figure 2. Smolt-to-adult survival rates (1989–1995), mean and 90% confidence interval, relative to recovery goal range.

Have the Lower Snake River and Columbia River dams been mitigated for?

Some people (primarily those in political and public forums) have claimed that the smolt transportation program, together with other dam design modifications, have mitigated the effect of the system of dams on the lower Snake River and Columbia River on Snake River spring and summer chinook salmon SARs. If this is true, because transported smolts are released below Bonneville Dam, any factor limiting Snake River spring and summer chinook salmon SARs must be exerting its influence between the time the smolts are released from the barges in the lower Columbia River and the time they return as adults. Potential factors include some suite of parameters acting in the estuarine and marine environment (e.g., predators, disease, competition, etc.) or harvest in ocean or Columbia River fisheries. Schaller et al. (1999) considered impacts on Snake River spring and summer chinook salmon from lower Columbia River and Pacific Ocean conditions by comparing stock:recruitment patterns between spring and summer chinook salmon with similar life history characteristics from populations occurring below the Snake River dams to Snake River basin spring and summer chinook salmon. Their analyses demonstrated that Snake River stocks had declined far more than lower Columbia River stocks and that factors occurring in the lower Columbia River and Pacific Ocean likely were not responsible for the collapse of Snake River spring and summer chinook salmon or their failure to recover.

Potential lower Columbia River and ocean impacts also can be viewed by comparing Snake River spring and

APPENDIX—SAR Calculation

Since 1988, passive integrated transponder (PIT) tags have been implanted into wild Snake River basin spring and summer chinook juveniles captured in rearing areas in up to 20 streams and near the head of Lower Granite pool as part of various research projects conducted by state, tribal, and federal entities in the Snake River basin. Each PIT tag contains a unique alphanumeric code allowing the identification of individuals (Prentice et al. 1990). As PIT-tagged Snake River chinook salmon smolts migrate downstream, they are detected in PIT-tag-detector facilities located in Lower Granite, Little Goose, Lower Monumental, and McNary dams. Depending on how each individual dam is being operated, at least 90% of the emigrating smolts are detected. The fish ladder at Lower Granite Dam contains a detector that all returning adults must pass. All detections are incorporated into the PIT Tag Information System (PTAGIS) database, managed by the Pacific States Marine Fisheries Commission, Portland, Oregon. This database can be accessed using pre-formatted queries provided by PTAGIS.

We searched the PTAGIS database for detections of wild spring and summer chinook smolts from Lower Granite, Little Goose, Lower Monumental, and McNary dams that were tagged in the Snake River basin and had migrated during 1989–1996. A comparison of arrival times at Lower Granite dam of PIT-tagged smolts with arrival times of the entire spring emigration revealed a very similar pattern.

Once a smolt was detected at one of these dams, any further downstream detections were omitted. The PTAGIS database also was searched for adult detections at the Lower Granite Dam PIT-tag detector for run years 1990–1998. Only detected adults that were detected as smolts were used in the calculation. The results of these searches were used to calculate *smolt-to-adult return rate* (number of returning adult detections in return years x+2 and x+3, divided by the number of smolts detected in smolt migration year x). We used the binomial distribution of these proportions to calculate the mean and 90% confidence interval for each smolt migration year (Zar 1974). Survival was not corrected for harvest, which we deemed insignificant for purposes of the calculation (TAC 1997; Petrosky and Schaller 1998).

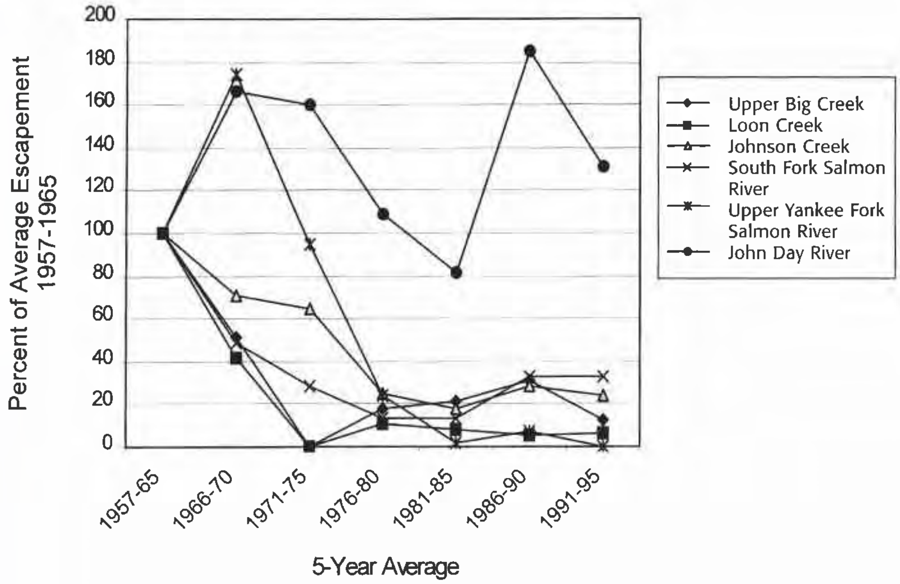

Figure 3. Escapement of spring and summer chinook salmon into index streams of the Salmon River basin and escapement of wild spring chinook salmon into the John Day River basin. Upper Big Creek—wild spring chinook, wilderness watershed; Loon Creek—wild summer chinook, wilderness watershed; Johnson Creek—natural summer chinook, managed watershed; South Fork Salmon River—hatchery-influenced summer chinook, managed watershed; Upper Yankee Fork Salmon River—hatchery-influenced spring chinook, managed watershed.

summer chinook salmon escapements to those of John Day River wild spring chinook salmon. John Day River spring chinook salmon smolts are similar in life history and emigration timing to Snake River spring and summer chinook salmon smolts (Raymond 1979; Lindsay et al. 1986). John Day spring chinook salmon also overlap in time and space with Snake River spring and summer chinook salmon (Schaller et al. 1999) during the period of initial estuarine and ocean entrance when year-class strength is determined (Pearcy 1992; Peterman et al. 1998). As such, John Day spring chinook salmon are exposed to the same lower Columbia River and Pacific Ocean conditions as Snake River salmon. John Day River spring chinook migrate past the same three dams on the Columbia River that Snake River spring and summer chinook salmon do. However, Snake River salmon also must migrate past the lower four Snake River dams and McNary Dam, or be transported. A comparison of adult escapement relative to the 1957–1965 average reveals that escapements of John Day River spring chinook, in stark contrast to those of Snake River spring and summer chinook salmon, are generally above the average of escapements exhibited during the 1957–1965 run years (Figure 3).

Harvest also is low on Snake River spring and summer chinook salmon. Average harvest rates in the mainstem Columbia River for spring and summer chinook salmon have declined steadily since the 1960s, and the average harvest rate during 1990–1997 was approximately 7% (TAC 1997). Information from ocean fisheries indicates that the harvest rate on Snake River spring and summer chinook salmon is less than 1% (J. Berkson, Columbia River Inter-tribal Fisheries Commission, pers. comm.). None of these harvest rates is sufficient to prevent recovery of Snake River spring and summer chinook salmon.

In light of this information, to conclude that the effects of the Snake and Columbia River dams on Snake River spring and summer chinook salmon SARs have been mitigated for requires a belief in the following three points. First, the cause of the demise of Snake River spring and summer chinook salmon did not exist prior to completion of dams on the lower Snake River but began exerting its influence after they were completed. Second, the cause occurs in the lower Columbia River or Pacific Ocean. Third, among Columbia basin anadromous stocks, the cause is specific to Snake River fish alone. There is no compelling reason to believe any such cause exists. Rather, we concur with Schaller et al. (1999) that efforts to date have not mitigated the effects of the lower Snake River and Columbia River dams on Snake River spring and summer chinook salmon.

The choice for recovery

The Northwest Power Planning Council's (NPPC) Independent Scientific Group examined the scientific basis for the Columbia Basin Fish and Wildlife Program (which directs salmon restoration in the Columbia basin) and concluded that the program was based primarily on the use of mechanistic solutions (ISG 1999). This recovery effort has been the largest and most expensive fish restoration effort in the world (Lee 1993). Indeed, there has been no larger scale test of the utility of a mechanistic foundation to elicit species recovery than has occurred in the Columbia and Snake river basins. After more than 25 years, the mechanistic solutions applied to recover Snake River spring and summer chinook salmon have not only failed to recover the fish, but they have not even stemmed the decline. The choice of mechanistic solutions to mitigate the effects of dysfunctional ecosystems to avoid employing more scientifically sound, but politically controversial solutions (e.g., restoring ecosystem functions), is not uncommon (Black 1994; Regier 1997). Unfortunately, when this occurs, environmental policy becomes both "self-frustrating" (Black 1994) and expensive (Black 1994; Bottom 1997), and the situation in the Columbia River basin has been no exception.

The NMFS (1995) has committed to choosing a strategy to recover Snake River spring and summer chinook salmon in 1999. Options under consideration generally involve combinations of smolt transportation and other engineering features, flow augmentation, and breaching of the four lower Snake River dams. Of these options only dam breach is consistent with abandoning a mechanistic foundation to achieve recovery. After comprehensive review, the NPPC's Independent Scientific Group concluded that salmon restoration in the basin would require some level of restoring natural river functions to the mainstem Snake and/or Columbia rivers (ISG 1999). In a separate process designed to respond to the federal biological opinion regarding Snake River salmon, the Plan for Analyzing and Testing Hypotheses (PATH) group, composed of scientists from state, federal, tribal, university, and private entities, was formed to provide the best available analyses supporting salmon recovery. These scientists engaged in a comprehensive and empirically rigorous process, and their analyses demonstrated that natural river actions produced higher survival benefits to spring and summer chinook salmon (and also fall chinook salmon and steelhead trout) than smolt transportation-based actions, and best met Endangered Species Act recovery standards. The PATH process also explicitly and quantitatively incorporated uncertainty into model parameters and found that natural river-based solutions were relatively insensitive to key uncertainties relative to the mechanistic-based solutions modeled. Across all uncertainties, natural river-based solutions produced the highest probabilities of recovery, with the least risk for failure, within 24 years (Marmorek et al. 1998).

Cairns (1993:201) stated, "Science can determine if restoration is possible; society must determine how much is desirable." The time for that determination has arrived for Snake River spring and summer chinook salmon. To date, salmon restoration efforts in the Columbia basin have "worked around the edges" of power generation and navigation (Volkman 1997). This was due to the hope that the Northwest could have the convenience offered by the eight dams occurring between Lewiston, Idaho, and the Pacific Ocean, and also have spring and summer chinook salmon as well as other anadromous fish. Analyses indicate that from a conceptual basis (ISG 1999) and an empirical basis (Marmorek et al. 1998), that hope will not be fulfilled. Any genuine attempt to recover these fish must be associated with restoring some level of pre-dam ecosystem function to the lower Snake and/or Columbia rivers by providing a more-natural, free-flowing river. However, the prospect of breaching the lower Snake River dams has been characterized by some as unthinkable. Conversely, rendering the salmon runs of the Snake River functionally extinct in less than 30 years is equally unthinkable to others. Ultimately then, how our society and culture assign importance to its responsibilities to future generations, short-term and long-term economies, and cultural heritage and social needs will determine if Snake River spring and summer chinook salmon are recovered. The foundation to achieve recovery has been identified; recovery will depend on whether that foundation is chosen.

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This article is the opinion of the authors and does not necessarily reflect the position of the American Fisheries Society (AFS). Readers with alternative perspectives are encouraged to submit them for consideration. Currently, AFS is drafting a position statement about dam removal in general. For information about getting involved, contact Christine M. Moffitt, cmoffitt@uidaho.edu.

NOTE from the authors:

In 1999, the **Idaho Chapter and Western Division** (composed of: Alaska, Arizona, British Columbia, California, Colorado, Hawaii, Idaho, Mexico, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming, Western Pacific islands and trust territories, Yukon) of the **American Fisheries Society** passed a **resolution** stating that:

1. Based on the best scientific information available, ...the four lower Snake River dams are a significant threat to the continued existence of remaining Snake River salmon and steelhead stocks; and
2. If society-at-large determines that Snake River salmon and steelhead are to be restored or recovered in their native ecosystem, then one biologically required action is to eliminate or greatly reduce impacts to salmon and steelhead from the four lower Snake River dams by removing, breaching, or bypassing the dams, or otherwise allowing the lower Snake River to flow freeely, without impoundment; and
3. In conjunction with action to allow the lower Snake River to flow freely, without impoundment, actions to address detrimental impacts to habitat, from harvest, or from hatcheries likely will be required to further increase the likelihood of recovering Snake River salmon and steelhead stocks.