APPENDIX 1

THE FALLACY OF UPPER SNAKE FLOW AUGMENTATION
THERE IS NO NEED TO DRAIN IDAHO FOR SALMON

PREPARED BY
IDAHO WATER USERS

THE IDAHO WATER USERS ARE COMPOSED OF:

THE COMMITTEE OF NINE
AND THE
IDAHO WATER USERS ASSOCIATION
410 S. ORCHARD, SUITE 144
BOISE, IDAHO 83705

JUNE 2001

CONTENTS

TABLES

FIGURES

June 20, 2001 DRAFT

The Fallacy of Flow Augmentation

There Is No Need To Drain Idaho for Salmon

"A significant question during this drought concerns the effectiveness of flow augmentation in improving fish survival. To address this question it is <u>important to first realize that a relationship of seasonal flow and smolt survival within a year, or a relationship of flow and survival between years, does not imply flow augmentation will increase survival</u>. Flow augmentation is produced by scheduled releases from storage reservoirs and by limiting municipal and agricultural withdrawals. Flow augmentation does not change the yearly averaged flow; it only reshapes the runoff over the season. Flow augmentation has a small and variable impact on the natural seasonal flow, temperature and turbidity, because the natural patterns are driven by the unregulated tributary runoff while flow augmentation is mostly from storage reservoirs.

Based on flow and smolt survival research, a relationship has been found between yearly-averaged flows and the survival of [spring/summer] chinook and steelhead passing through the hydrosystem. However, the same research demonstrates that seasonal flows are not correlated with hydrosystem survival. Because flow augmentation makes up a small portion of the seasonal flow, it too is not correlated with smolt hydrosystem survival.

…Simply put, <u>flow survival studies conducted over 8 years indicate that the impacts of flow augmentation on smolt survival are not measurable at best, may be neutral, and in some situations may decrease survival</u>.
(Anderson 2001, emphasis added)

Introduction

Idaho water users support salmon recovery. However, development of water resources in the Upper Snake River Basin did not cause the decline of fish populations, and reducing those water uses will not reverse the trend. Continued calls for ever-increasing amounts of water from southern Idaho ignore the fact that there is no significant biological benefit from a program that has enormous economic and social costs.

Salmon and steelhead runs in the Snake River basin are in trouble – no argument there. The big debate is how to fix the problem. Many people are calling for more water to be sent down the Snake River during the spring and summer, mostly to help juvenile fish on their way to the ocean. This approach is known as "flow augmentation." The argument for flow augmentation sounds simple and logical – the fish are in trouble, fish need water, so more water will help solve the problem. Right? Wrong! At least not by taking more water from the Upper Snake River.[1] If Snake River flows had fallen over time, before or during the salmon decline, the theory might make more sense. But the flows are virtually the same as they were 100 years ago. In fact, as a result of water returning to the river from irrigation ("return flows"), water supplies have <u>increased</u> during the summer, one of the key times when flow augmentation advocates suggest that more water is needed to restore the "natural river."

If there was convincing scientific evidence that more Upper Snake River water would significantly help salmon, there would be a good argument for augmentation. But science has discounted the studies that started the myth, and more recent studies do not support flow augmentation.

In this paper, we present an overview of water in the Upper Snake basin including the history and the nature of water uses in Idaho. We discuss the hydrology of the Upper Snake River as it applies to stream flows and augmentation efforts. We look at the impacts on the survival of listed fish populations resulting from increased Upper Snake River flows. We talk about recovery options that are more likely to increase fish

[1] In this paper, Upper Snake means the Snake River basin above Hells Canyon in Idaho.

populations than flow augmentation. Finally, we show the economic and social impacts of flow augmentation on the people of Idaho.

Overview of Idaho and the Upper Snake Basin

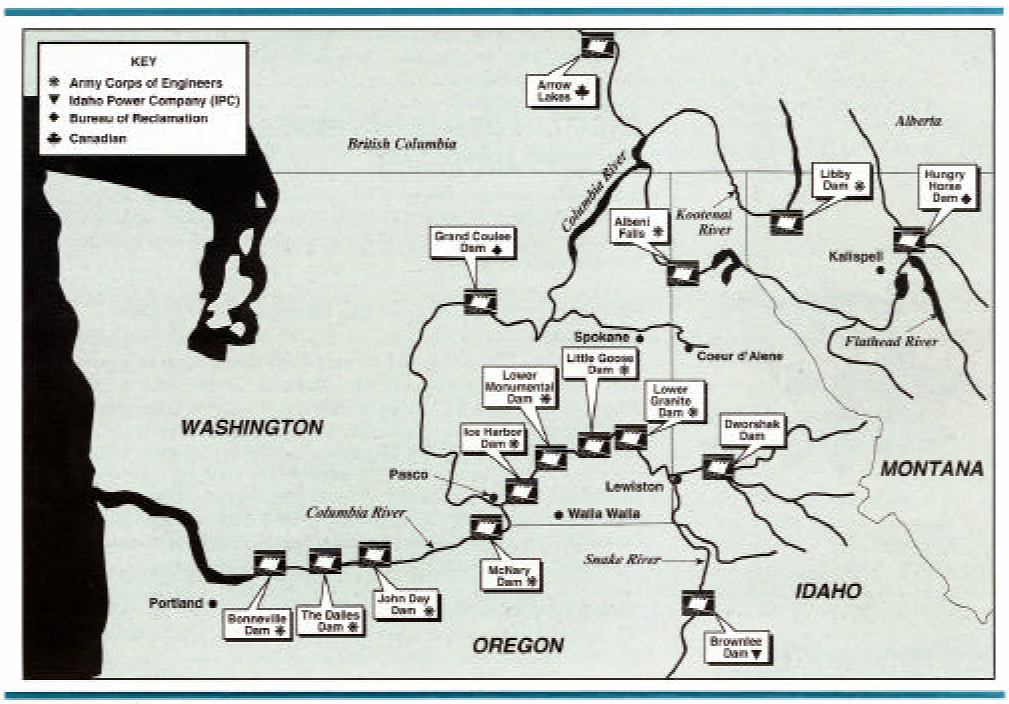
Water is the backbone of Idaho's economy. In addition to irrigation, other water uses — including towns and cities, industries, hydropower generation, and recreation — depend on significant amounts of water. Combined, Idaho water uses consume about 5 million acre-feet (MAF) per year, which is about 7 percent of the total annual outflow from Idaho into the Columbia River system of about 70 million acre feet (MAF) (IWRB 1996).

Beginning in 1836 on the Nez Perce Reservation, irrigation expanded to encompass about 1.5 million acres in 1909 (Arrington 1986; 1910 Census). Continued development of irrigation in the first half of the 20th century was aided by storage facilities constructed by the United States. About 6.5 million acre-feet of storage space is available for use in the Snake River basin in Idaho as a result of federal projects (U.S. Bureau of Reclamation 1998). Further development of irrigation occurred as the number of acres irrigated by wells increased significantly from the 1950s through the 1970s, and leveled off during the 1980s at about 1 million acres (IWRB 1996). In 1996, over 3 million acres were irrigated from surface and ground water sources in the Snake River Basin (IWRB 1996).

All major dams on the lower Columbia and Snake Rivers (Figure 1) were authorized and funded by Congress or licensed by the Federal Energy Regulatory Commission (formerly Federal Power Commission). There are 20 major reservoirs in the Upper Snake River basin (Figure 2). All but two of the reservoirs in southern Idaho were completed prior to 1960, long before the precipitous decline of anadromous fish runs in Idaho (Bureau of Reclamation 1998).[2]

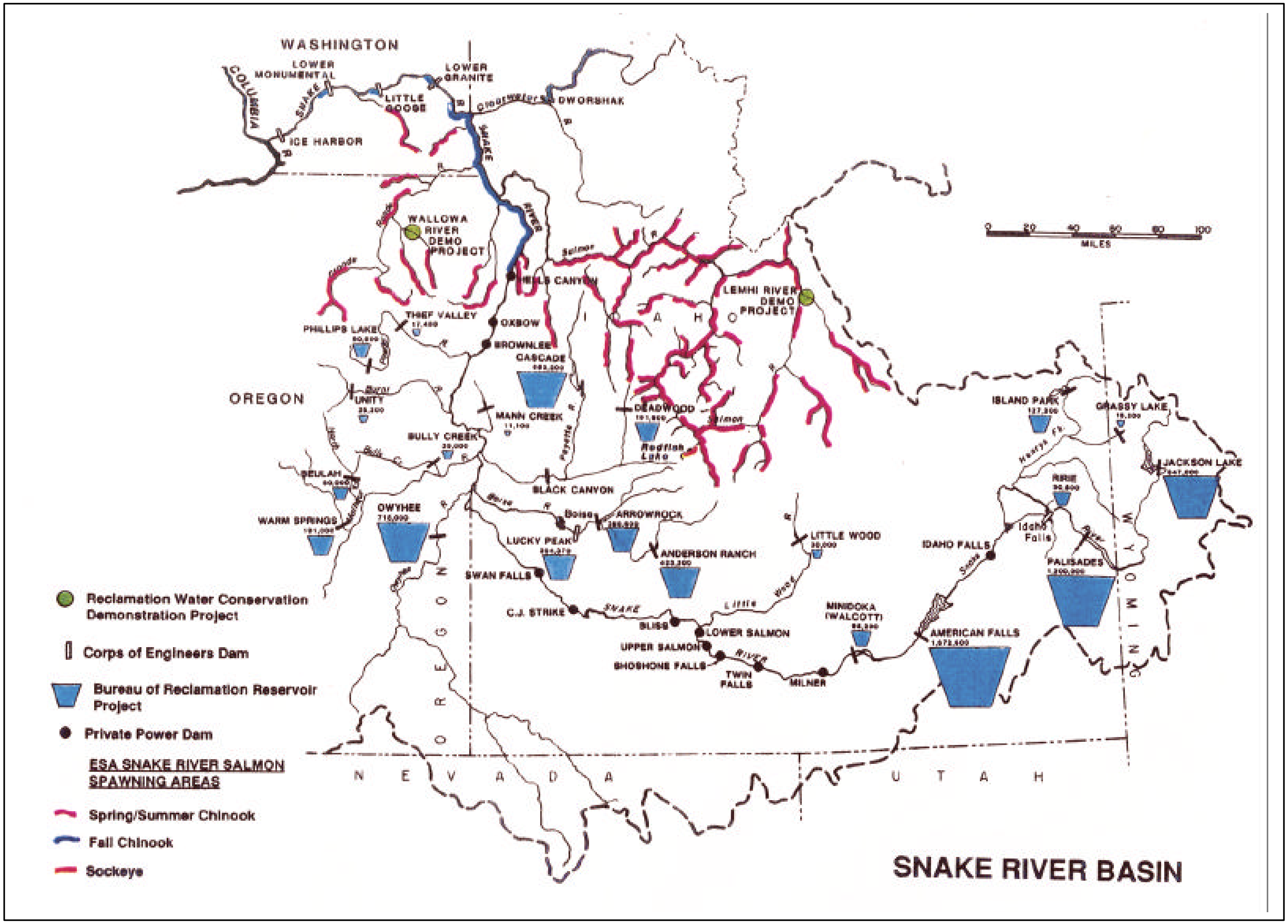
[2] Two small reservoirs, Mann Creek (11,000 af) and Ririe (91,000 af), were completed after 1960.

Figure 1. Major Dams on the Lower Columbia and Snake Rivers



Source: Interim Columbia and Snake Rivers Flow Improvement Measures for Salmon — Supplemental EIS, Fact Sheet No. 1. October 1992.

Figure 2. Snake River Reservoirs and Spawning Areas



From the time of the Lewis and Clark expedition in 1805 to the present, the federal government has been the primary proponent for developing and managing natural resources in the Snake and Columbia River basins. Federal policies and actions have been directly responsible for almost every factor of salmon decline: ocean and in-river harvests; hatcheries; transportation; hydropower dam blockage and inundation of habitat; turbine-related morality; delay of juvenile and adult migration; increased predation in reservoirs; water withdrawals and storage; unscreened irrigation diversions; water quality degradation; grazing; logging; mining; marine mammal predation; drought; and disease.[3] For example, numerous Congressional Acts promoted settlement and development of the Snake and Columbia River basins including the Donation Land Act (1850-1855), the 1862 Homestead Act, the 1877 Desert Land Act, and the 1894 Carey Act (U.S. Army Corps of Engineers 1995; App. F, p. 2-2). Railroads were given land grants by Congress to further encourage development (Id.). Beginning with the 1902 Reclamation Act and continuing with hydropower studies and authorizations of Columbia River basin projects from 1927 on, Congress promoted water development in the Snake and Columbia River basins. Grazing, logging, and mining on federal lands have been encouraged by Congress. The United States entered into treaties with Canada on upper Columbia River development and with various foreign powers on ocean harvests. 15 U.S.T. 1555. Congress passed the Marine Mammal Protection Act, which has led to dramatic increases in predation on salmon. 57 FR 14660. Federal agencies manage 96 million acres (about 55 percent of total acreage) in the Pacific Northwest under Congressional authority and appropriations (U.S. Army Corps of Engineers 1995). Federal agencies, including NMFS and USFWS, also manage fish and wildlife, and Congress authorized and continues to fund hatcheries.

Given 150 years of federal promotion of resource development in the Pacific Northwest, it is an outrage to ask Idaho water users to sacrifice their livelihoods to offset impacts on salmon caused by circumstances beyond their control.

[3] The National Marine Fisheries Service cites these factors for the decline of the salmon populations in the final rules listing Snake River spring/summer and fall chinook as “threatened” and sockeye as “endangered” under the Endangered Species Act. 56 FR 58619 (November 20, 1991); 57 FR 14654 (April 22, 1992).

Hydrology of the Upper Snake River

Overview

As previously stated, total annual outflow from Idaho into the Columbia River system is about 70 million acre feet (MAF), or roughly one-third of the total flow of the Columbia River (IWRB 1996). About one-half of this flow is provided by northern Idaho tributaries and one-half is from the Snake River. Average annual flow of the Snake River as it leaves the state at Lewiston is about 36 MAF (Id.). Roughly one-third of this amount comes from the Upper Snake River above Hells Canyon and about one-half comes from the Salmon and Clearwater River basins (Id.). The remainder is contributed from smaller tributaries in Oregon, Washington, and Idaho.

Records of stream flow and irrigated acreage do not extend back to the beginning of irrigation in the mid-1800s, but data is available since 1910. Reductions to stream flow caused by the construction of reservoirs and development of irrigation on about 1.5 million acres should be reflected in the flow records for the Snake River at the Weiser gage, located just above Brownlee Reservoir. However, the historical record does not reflect a significant decrease in flow. Conversely, average annual flows have remained constant since 1910, as discussed in the following section.

Historical Stream Flow Records

Figure 3 shows the actual mean annual flow at Weiser for the period 1911-1997. As can be seen from the trend line plotted on the graph, average annual flows have remained constant over the past 85 years despite water development in the Upper Snake River basin.[4]

[4] An ordinary least squares (OLS) trend line shows a slight increase of about 10 cfs per year in the mean annual flow over the years. A K-T (Kendall-Theil Robust) trend line shows a slight decrease of less than 2 cfs per year in the mean annual flow over the years. The OLS trend analysis is well recognized as an acceptable determination of change with time but can be sensitive to extreme values, particularly when those values occur near the beginning or end of the period of record. To better analyze whether a change in discharge of the Snake River at Weiser exists, the nonparametric K-T trend analysis was also completed. The K-T analysis is insensitive to extreme values, regardless of where in the record they occur, because it is based on median values and ranking instead of means (Helsel and Hirsch, 1993). The K-T analysis is not inconsistent with the OLS analysis for the discharge of the Snake River at Weiser. Even though the K-T analysis shows a

Figure 4 shows the actual mean summer flow at Weiser for July 1 through August 31 for the period 1911-1997 without flow augmentation. This period was selected to match the time during which flow often falls short of NMFS' targets and the season for which there has been concern over juvenile fall chinook migration. Again, the trend line plotted on the graph shows that the measured flows of the Snake River at Weiser have remained constant over the past 85 years.

Similarly, at Lower Granite the historical hydrology does not indicate decreasing flows. Figures 5 and 6 show a trend of increasing mean annual and summer (July 1 through August 31) flows of the Snake River at Lower Granite for the period 1911-1997.[5]

Figure 7 contains the same mean annual flow data used to prepare Figure 3 and, in addition, shows the development of irrigated acreage in Idaho and the development of Upper Snake Bureau of Reclamation (Reclamation) water storage.[6] Figure 7 shows that irrigated acreage significantly increased and most of the Reclamation storage development occurred after flow measurement records for the Snake River at Weiser began. Figure 7 also shows both irrigated acreage and Reclamation storage increasing throughout the period but without a significant change in the mean annual flow of the Snake River at Weiser.

---

slight decrease in flow from year to year (162 cfs in 89 years), neither the decrease in discharge of the K-T analysis nor the increase in discharge of the OLS analysis are statistically significant. That is, the null hypothesis of slope equal to zero ($H_0: ß_1 = 0$) could not be rejected for either analysis.

[5] Flow augmentation since 1983 has been subtracted from gage data before plotting the mean flows on Figures 4 and 6.

[6] Reclamation storage represents all reservoirs above Brownlee. The irrigated acreage is taken from Census Reports and include all irrigated acres in Idaho (United States Census Office, 1902-1997). Census Reports do not separate the number of irrigated acres by river basin within a state. The irrigated acreage reported for Idaho includes acreage outside of the Snake River basin upstream from Weiser including the Bear and Salmon River drainages. Similarly, the reported irrigated acreage does not include acres irrigated from the Snake River basin above Weiser located in Wyoming, Nevada, and Oregon. The differences in the chart from actual acreage irrigated from the Snake River basin upstream from Weiser is minimal since most of the irrigated acreage in Idaho is irrigated from the Snake River basin upstream from Weiser and most of the acreage irrigated from the Snake River basin above Weiser is in Idaho.

Figure 3

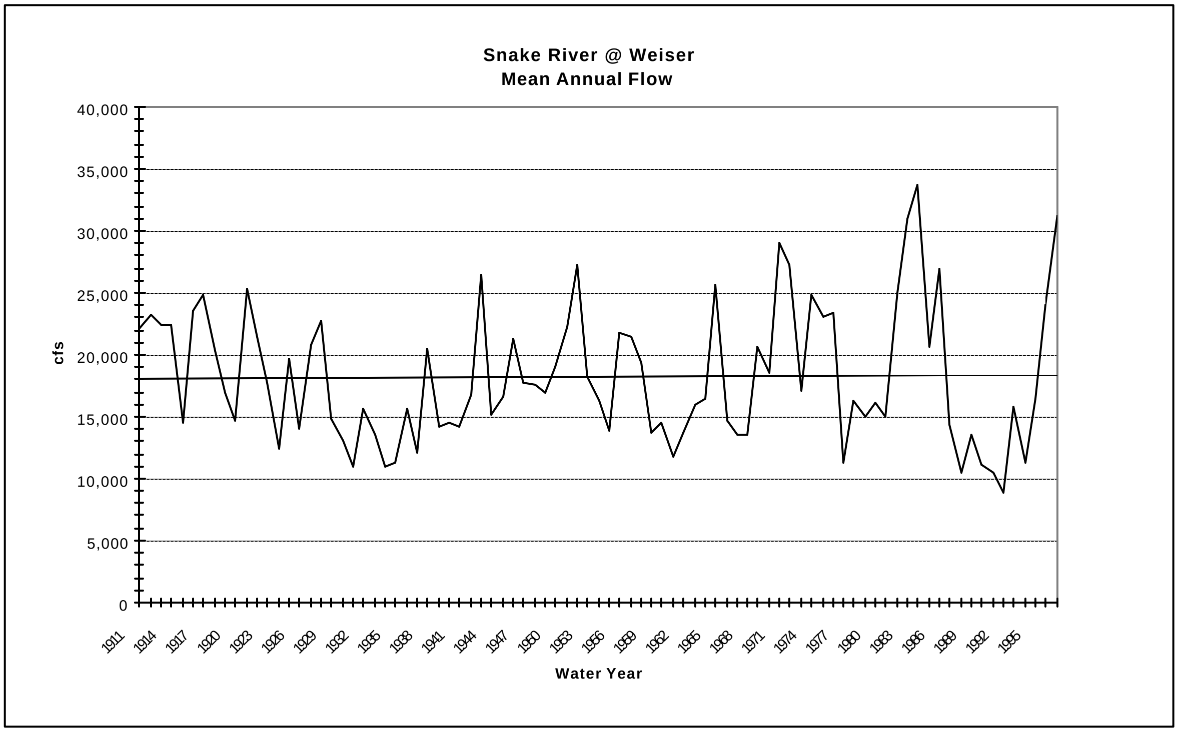


Figure 4

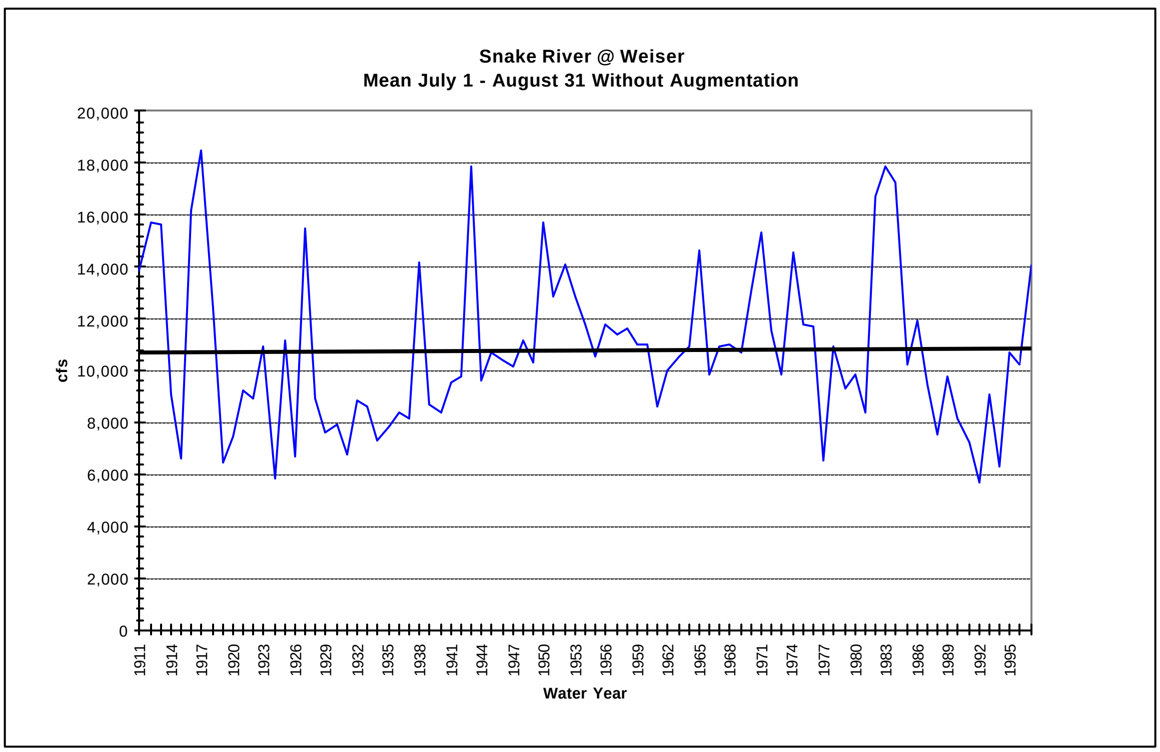


Figure 5

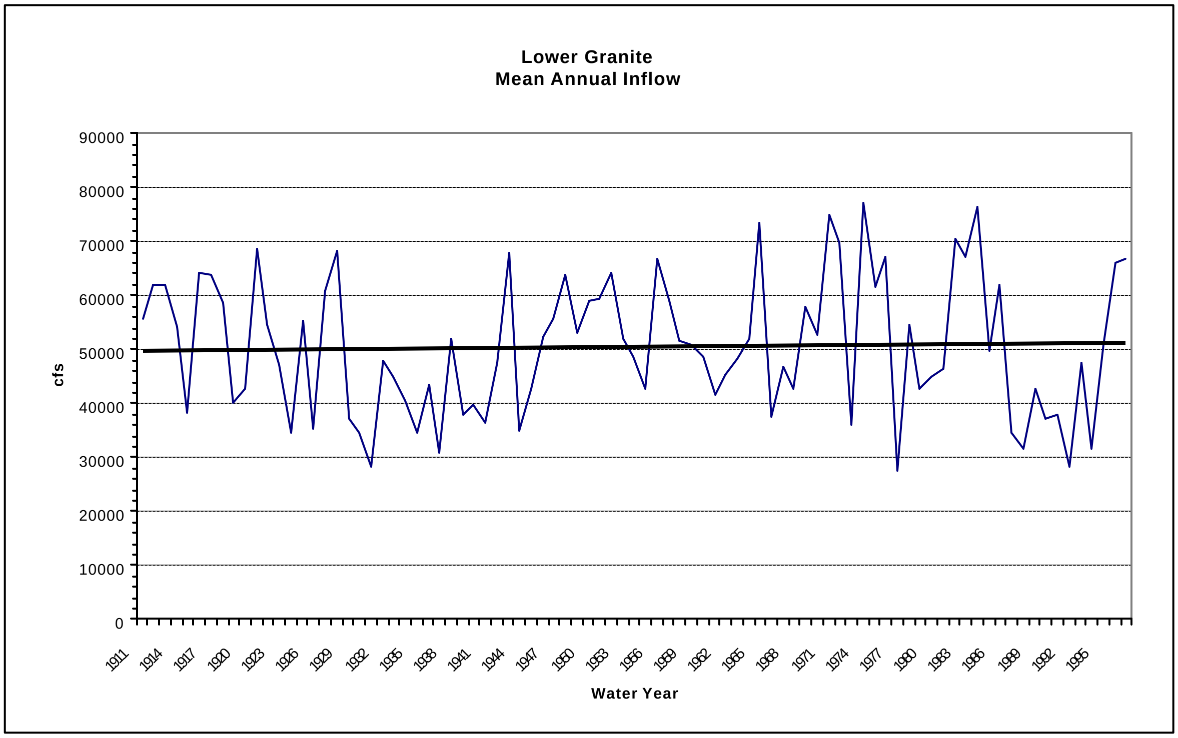


Figure 6

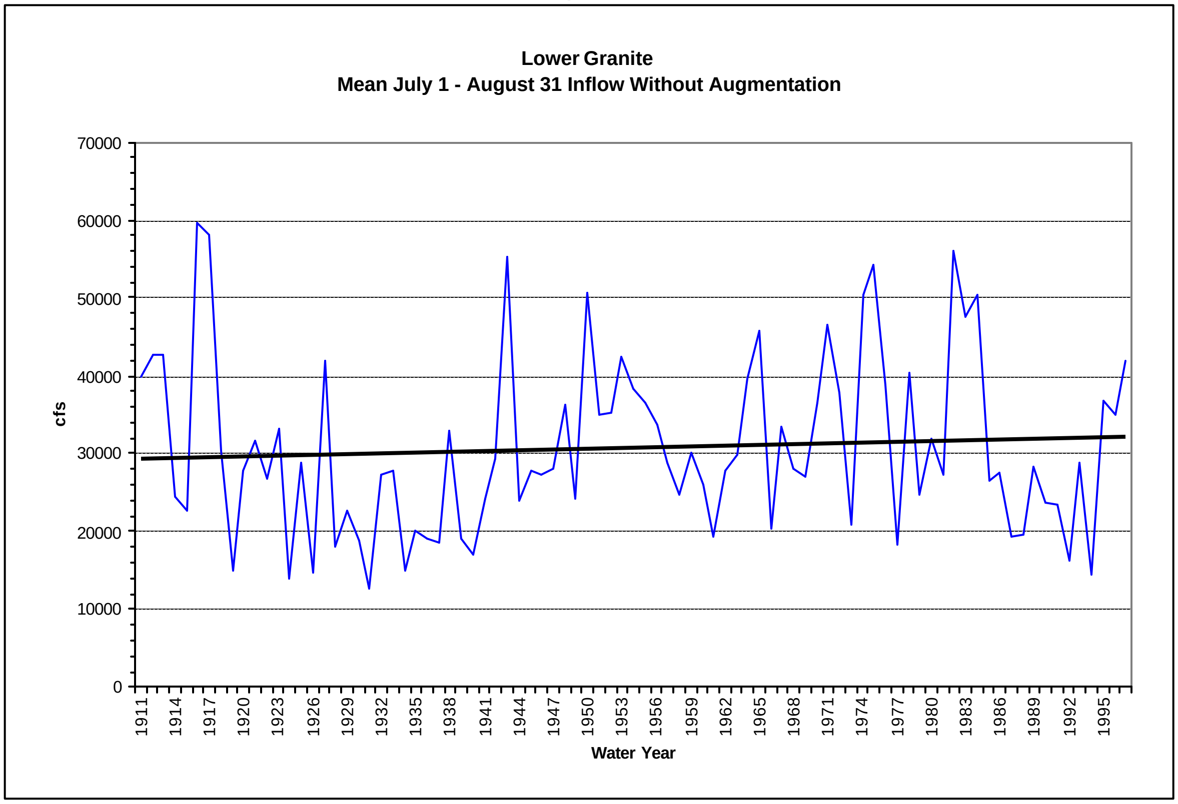
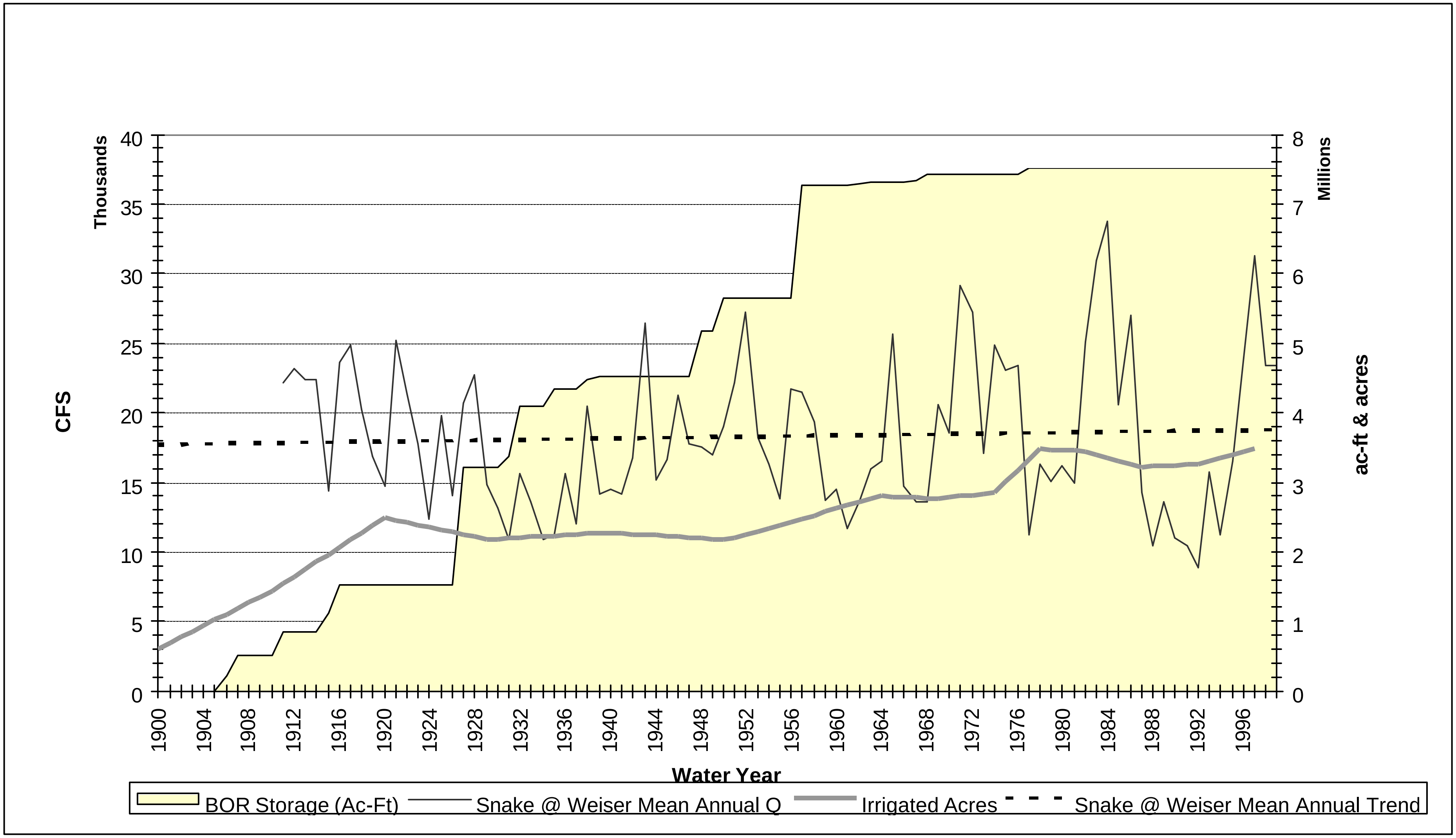


Figure 7. Snake River @ Weiser Mean Annual Flow, Irrigated Acres and Reclamation Storage.



In summary, the quantity and timing of Snake River flow have never changed significantly. In 1995, the National Research Council recognized this fact:

> "*Because there has not been a major shift in the Snake River hydrograph, it is doubtful a priori that the declines in Snake River salmon stocks are due to or reversible by changes in the seasonality of the flow regime of the Snake River alone*" (NRC 1995 at 193).

Flow Augmentation Efforts

Flow augmentation in the Columbia River basin began in 1983 under a water budget recommended by the Northwest Power Planning Council (Olsen 1998a). The water budget was developed to aid salmon migration. The budget steadily increased from less than 4 MAF (including about 300,000 af from Idaho) in the early years to over 10 MAF in 1994 (including about 2.7 MAF from Idaho) (Id.). Idaho's share comes from three sources: the U.S. Army Corps of Engineers' (Corps) Dworshak Reservoir (about 2 MAF), Idaho Power Company's Brownlee Reservoir, and Reclamation's Upper Snake reservoirs (Id.). Figure 8 shows the amount of flow augmentation from each source from 1987 through 1999. Figure 9 shows the combined adult returns of wild salmon and steelhead to the uppermost dam on the Snake River from 1964-1999. Obviously, flow augmentation has not reversed the decline of fish populations.

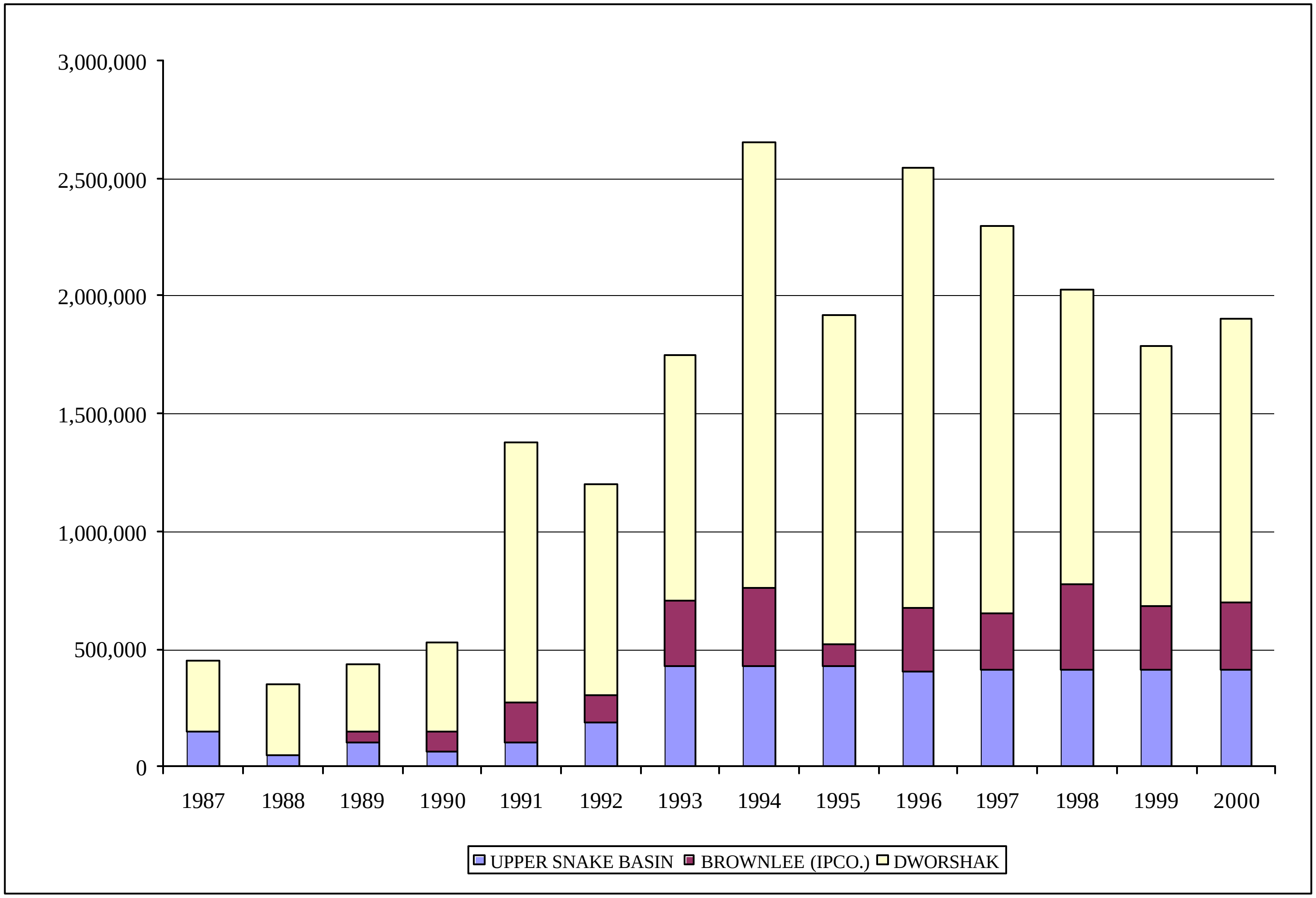
Since 1993, Reclamation has augmented flows below Hells Canyon using 427,000 af of water per year made available from its own uncontracted reservoir space and water purchased or rented from willing sellers in the Upper Snake River basin water. This flow augmentation was required by the National Marine Fishery Service (NMFS) 1995 Biological Opinion on operation of the Federal Columbia River Power System (FCRPS).

In 1999, in response to a NMFS request to expand Upper Snake flow augmentation, Reclamation completed an analysis of obtaining an additional 1 MAF from the Upper Snake River basin for flow augmentation (Bureau of Reclamation 1999). Also in 1999, the Corps of Engineers, Bureau of Reclamation, Bonneville Power Administration, and Environmental Protection Agency released the Draft Feasibility Report/Environmental Impact Statement ("EIS") for the Lower Snake River Juvenile Salmon Migration Study (U.S. Army Corps of Engineers 1999). This EIS eliminated the MAF alternative for a variety of reasons: 1) it is unlikely to provide better biological benefits than other alternatives; 2) high costs and impacts; 3) numerous implementation issues; 4) legal and water supply uncertainties; 5) inadequacy of study; and 6) lack of public acceptability (Id. pp. 3-15, 3-16, 5.16-3, 5.16-4).

Water Conservation

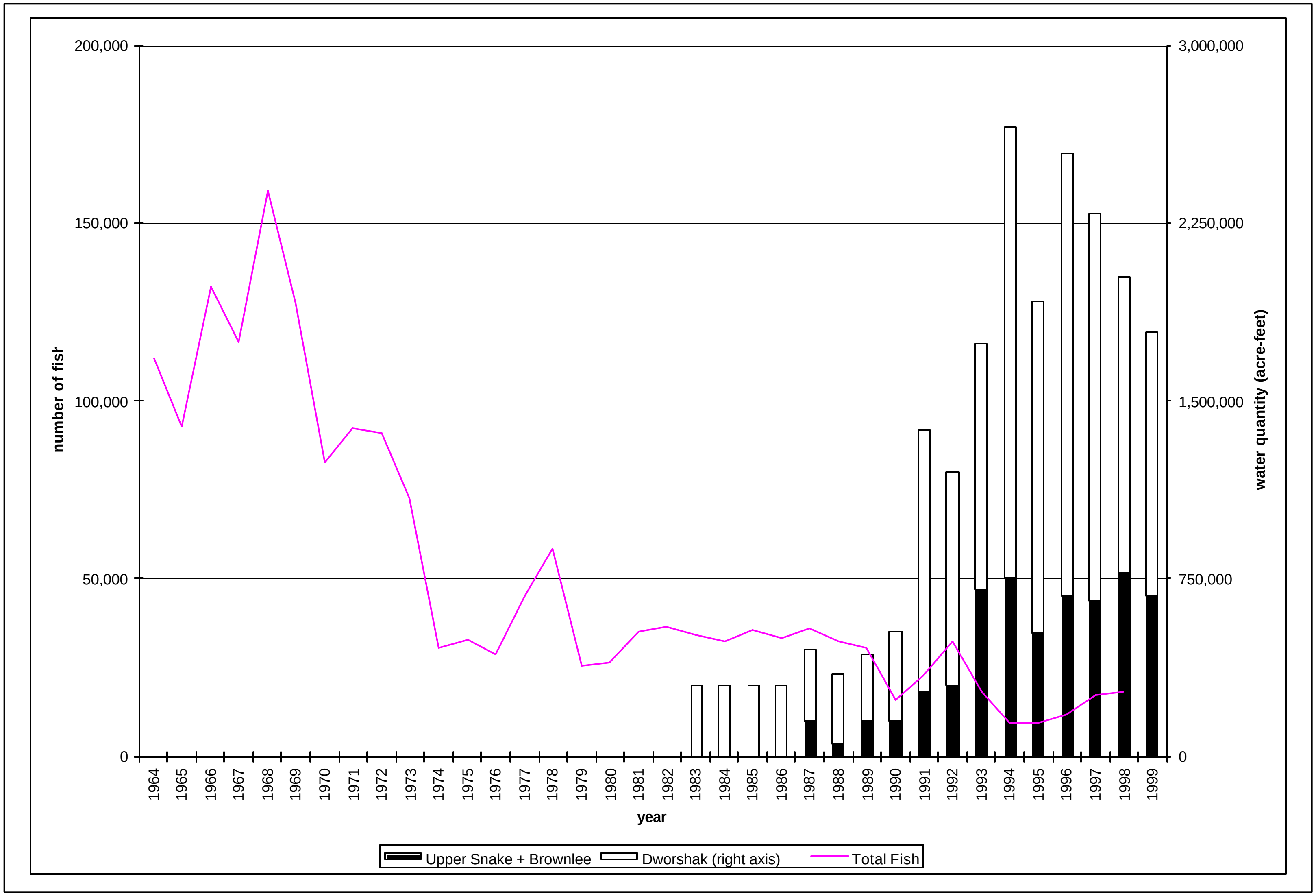
Some fishery interests advocate improved irrigation efficiency to increase the water available for instream flows in the lower Snake River (or mitigate the impact of a federal/tribal taking of water). However, on an annual basis, the flow of the lower Snake River would not be significantly increased by water conservation through improved irrigation efficiency because water losses from irrigation inefficiency already return to the river above Hells Canyon (Bureau of Reclamation 1999, pp. 3-4). Moreover, increased efficiency is likely to reduce return flows during the summer months—a time when many advocate that additional flows are needed.

Figure 8. Flow augmentation table and graph.



	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
UPPER SNAKE BASIN	150,000	50,000	100,000	63,000	100,000	189,000	424,590	428,112	427,235	406,863	409,219	409,154	409,153	409,253
BROWNLEE (IPCO.)			50,000	87,000	174,000	110,000	277,000	327,000	90,000	269,064	244,330	362,600	269,800	286,000
DWORSHAK	300,000	300,000	280,000	378,800	1,106,000	900,000	1,042,131	1,900,000	1,400,000	1,866,771	1,638,966	1,253,000	1,108,000	1,204,500
IDAHO CONTRIBUTION	450,000	350,000	430,000	528,800	1,380,000	1,199,000	1,743,721	2,655,112	1,917,235	2,542,698	2,292,515	2,024,754	1,786,953	1,899,753

Figure 9. Snake River flow augmentation compared to adult returns of wild salmon and steelhead to the uppermost dam on the Snake River below Hells Canyon (Ice Harbor 1964-68; Lower Monumental Dam 1969; Little Goose Dam 1970-74; Lower Granite Dam 1975-99).



Fish Survival and Upper Snake Flow Augmentation

One of the well-publicized theories to help recover listed Snake River salmon and steelhead is to use water from Idaho reservoirs to augment the flow of the Snake River at Lower Granite Dam. The reasons range from using augmentation water to "flush" juvenile fish through the reservoirs on the lower Snake and Columbia Rivers, to providing additional flow to operate the fish collection facilities efficiently so more fish will be transported, to using augmentation water for temperature control. This discussion will disprove that theory.

The Origin and Perpetuation of the Flow Augmentation/Fish Survival Myth

The theory that salmon survival is related to flow can be traced to a paper published in 1981 by Carl Sims and Frank Ossiander (*see also* Appendix 2). These researchers analyzed the annual values of juvenile salmon survival in relation to Ice Harbor flows for 1973-1979. In recent years, this early research has been discounted as a result of problems with the data, assumptions, and analysis (Williams and Matthews 1995; Steward 1994). Moreover, some of the salmon mortality attributed to low flow may have been due to passage facilities at the dams, which have been significantly improved over the past 20 years (Williams and Matthews 1995). Most importantly, the Sims and Ossiander research, like most of the subsequent studies, failed to recognize that flow augmentation does not recreate the same conditions as naturally higher flows.

NMFS continues to rely on the myth that Upper Snake River flow augmentation will significantly benefit anadromous fish (NMFS 2001). However, as a result of continuing research, NMFS is beginning to recognize that: 1) "*relationships between flow and survival and between travel time and survival through impounded sections of the lower Snake River*" are neither strong nor consistent; and 2) another part of the flow augmentation myth—a supposed causal relationship between flow and smolt-to-adult returns (SAR)—is not supported by recent data and analyses (NMFS 2000a, pp. 17, 22, 52).

As the portion of the myth that flow augmentation benefits salmon through the hydrosystem has been exposed, proponents have turned to alleged benefits above and below the dams. As discussed below, the data do not support purported benefits above Lower Granite Reservoir. Moreover, there is no biological data to support flow augmentation benefits below the FCRPS in the estuary or near-shore environment, and hydrological analysis concludes that little or no benefit from Upper Snake River flow augmentation is even possible due to the small magnitude of additional flow that can be made available under any scenario.

Yearling Migrants (Spring/Summer Chinook and Steelhead)

Flow augmentation has not been clearly demonstrated to provide direct survival benefits for yearling migrants. Instead, NMFS speculates that there may be indirect benefits:

> "*A strong and consistent relationship exists between flow and travel time. Increasing flow decreases travel time. Thus, although no relationship appears to exist within seasons between flow and yearling migrant survival through the impounded sections of the Snake River, by reducing travel times, higher flows* <u>*may*</u> *provide survival benefits in other portions of the salmonid life cycle and in free-flowing sections of the river both upstream and downstream from the hydropower system. Snake River basin fish evolved under conditions where the travel time of smolts through the lower Snake and Columbia Rivers was much shorter than presently exists. Thus, higher flows, while decreasing travel time, may also improve conditions in the estuary and provide survival benefits to juvenile salmonids migrating through the estuary or the Columbia River plume. By reducing the length of time the smolts are exposed to stressors in the reservoirs, higher flows also* <u>*likely*</u> *improve smolt condition upon arrival in the estuary*" (NMFS 2000a, p. 22, emphasis added).

This speculative description of the possible benefits of decreased travel time from flow management in the face of weak and inconsistent data is evidence that there is no rational basis for flow augmentation and that inclusion of such augmentation from the Upper Snake is arbitrary without supported careful analysis from the scientific evidence in the record. Careful analysis of the mechanisms, uncertainties, and quantification of these speculative indirect impacts is conspicuously absent. Finally, survival is the issue, not travel time.

Moreover, although NMFS reports a strong association between travel times and flow and concludes that travel time is a function of flow (NMFS 2000a, pp. 12-17, 22), the correlation appears to be invalid due to a collinear relationship between flow and time of year (photoperiod).[7] Photoperiod is known to be a factor in smolt travel time; increased photoperiod is correlated with decreased travel time (NMFS 2000a, p. 44). In fact, analysis of smolt migration through Lower Granite Reservoir from 1987-1995 concludes that photoperiod provides a better basis to predict travel time than flow, and that travel time can be predicted by flow only because the relationship between flow and photoperiod is collinear during the spring. (IWU 2000a, Attachment 2). For example, flows measured by the U.S. Army Corps of Engineers at Lower Granite Dam at 15-day intervals in 1995 and 1996 are given in Table 1. As seen in the table, there is a consistent increase in flow over time during the spring migration of smolts. Both flow and photoperiod increased synchronously over the period of study.[8] Thus, conclusions concerning flow as the variable controlling travel time are highly speculative.

Table 1. Flow at Lower Granite Dam.

Date	1995	1996
April 1	46 kcfs	81 kcfs
April 15	78 kcfs	132 kcfs
April 30	84 kcfs	98 kcfs
May 15	96 kcfs	139 kcfs
May 30	111 kcfs	156 kcfs
June 14	120 kcfs	170 kcfs

NMFS and other agencies should further evaluate potential collinear effects among variables before arriving at firm conclusions for yearling migrants. As discussed below for sub-yearling migrants (fall chinook), confounding effects probably exist from collinearity between flow and other environmental variables such as water temperature and turbidity. In addition, the relationship of survival to other independent variables such as the physiological state of the juveniles, size of the juveniles, predation, competition, and ocean conditions should be explored.

[7] In statistics, the term "collinear" means that the predictor variables (e.g., temperature, flow, travel time, and time of year) are highly correlated with each other. Thus, any correlation of the variables to the dependent variable (salmon survival) is confounded by the other variables.

[8] Cooler weather at the end of April 1996 slowed snowmelt and resulted in a temporary flow reduction for that year for the period that included April 30.

Sub-Yearling Migrants (Fall Chinook)

A review of available data and recent research supporting and defending flow augmentation for fall chinook leads to the conclusion that Upper Snake River flow augmentation is not of significant benefit to survival for the following reasons:

1. Natural variations in flow have been the focus of analysis, not flow augmentation. Upper Snake River flow augmentation does not create changes in important environmental variables such as date of migration, temperature, and turbidity.
2. Flow is a poor predictor of survival and the effect of flow on survival cannot be reliably estimated. Other environmental variables such as time of migration, water temperature, and turbidity are more strongly correlated with survival.
3. Survival is also more likely related to other independent variables such as the physiological state of the juveniles, size of the juveniles, predation, competition, and other factors.
4. There is no statistically significant relationship between flow and spawner-recruit data for fall chinook over brood years 1964-1994.

Recent Studies Above Lower Granite Reservoir

There are serious flaws in recent biological research that is being used to support and defend flow augmentation to benefit ESA-listed anadromous fish runs (IWU 2000a, Attachment 1). The published studies from this research raise serious concerns about the methods being used in these studies and the conclusions being reached from the results (e.g., Muir et al. 1999; Connor et al. 1998; Connor et al. 2000). These concerns include:

1. The definition and propriety of "flow exposure indices";[9]
2. Confounding effects from correlation between flow and other environmental variables such as photoperiod, water temperature, and turbidity; and
3. The relationship of survival to other independent variables such as the physiological state of the juveniles, size of the juveniles, predation, competition, and other factors.

[9] Flow exposure indices have been used by researchers to represent the flows experienced by fish during active migration.

In other words, changes in survival appear to be in response to variables other than flow. Flows naturally decrease during the migration period for juvenile fall chinook. However, other variables also change during this same period, which can lead to spurious correlations of flow to survival. For example, although there may be a relationship between certain measures of flow and the travel time of certain juvenile migrants, there does not appear to be a relationship between travel time and juvenile survival. This strongly indicates that other river conditions such as temperature or turbidity and fish condition such as size may be more important to fish survival than simply the quantity of flow.

Most agencies simply assume, without detailed analysis, that flow augmentation is beneficial to listed species (e.g., Reclamation 1998; NMFS 2000f; NMFS 2001; IDFG 2001). However, Anderson et al. statistically demonstrated that during the season, migration timing and temperature are better predictors of survival than flow — later timing and higher temperatures reduce survival (Anderson et al. 2000).[10] In fact, multiple correlation rejects seasonal flow as a predictor of survival. This means that within-season flow changes, such as through flow augmentation, are even less likely to be significantly correlated with survival than between-season changes. Anderson et al. further demonstrated that the correlation between flow and water temperature for Snake River flow augmentation can reverse from natural conditions so that flow augmentation increases Snake River temperature. Because temperature is likely to be a causative factor in the survival pattern (higher temperature increases predation), when augmentation increases temperature, it decreases survival. In other words, summer flow augmentation with warm, clear water from Brownlee decreases survival for Snake River fall chinook (Anderson et al. 2000, p. 59).

[10] The occurrence of higher flow also correlates with the occurrence of lower temperature and earlier migration (earlier release of fish). While temperature and migration timing correlate with survival, flow and travel time do not. However, since all of the variables change in synchrony, each factor individually correlates with survival.

Flow v. Survival

Anderson et al. evaluated spawner-recruit data for fall chinook extending back to the 1960s.[11] No significant relationship between natural variations in flow and recruits per spawner was found. Although not statistically significant, a small positive relationship was found. However, even if additional data proves the relationship to be valid, the effect of natural variations in flow is not biologically significant. Moreover, as discussed in the previous section, it must be emphasized that it is not clear that flow is the operative variable, and it is not apparent that flow augmentation provides any of the benefits of a naturally high-flow year such as cooler, more turbid water.

High mortality during various life stages contributes to low overall survival. For example, optimistic survival fractions for fall (ocean-type) chinook are: spawning to juvenile migrant (≈ 0.115), juvenile migration (≈ .610), marine feeding (≈ .015), adult migration (≈ .600), and pre-spawning (≈ .950). Total life cycle survival can be approximated by multiplying the survival fractions, i.e., 0.115 x 0.610 x 0.015 x 0.600 x 0.950 ≈ 0.0006 (IWU 2000a, Attachment 4). Thus, a change in survival for juvenile migration (≈ 0.610) represents less than 1 percent of the total life cycle. A similar example for spring/summer Snake River chinook also shows that the survival of juvenile migrants (≈ 0.60) is a tiny fraction of total life cycle (≈ 0.00014) (BPA et al. 1999, pp. 4-9 – 4-11). Thus, Idaho Water Users believe that there is little prospect for associating SAR or other life cycle measures of survival with environmental variables such as flow.

Flow and Velocity

Some biologists and various groups suggest that downstream migration of juvenile salmon could be improved by increasing the rate of flow through the reservoirs along the lower Snake and Columbia Rivers to speed up migration. Flow augmentation is futile to mitigate the velocity reductions resulting from dams on the lower Snake River (Dreher 1998, p. 12). Adding 1 MAF annually to existing flows results in less than $^{1}/_{10}$th of 1 mile per hour increase in velocity through the Lower Snake River reservoirs (Id. 1998). More than 160 MAF (over 4 times the existing flow) would be required to restore pre-dam

[11] Recruits are fish returning to the mouth of the Columbia River from the original spawning adults

velocities (Id.). Clearly, existing and proposed levels of flow augmentation from the Upper Snake River have an insignificant effect on water velocity through the lower Snake River (Id.).

Estuary/Plume Effects

In a further attempt to find some basis for flow augmentation, NMFS has suggested that higher flows might improve habitat in the estuary and provide survival benefits to juvenile salmonids migrating through the estuary or the Columbia River plume (NMFS 2000, p. 53).

As discussed above under *Historical Stream Flow Records*, the volume and pattern of flow in the Snake River upstream from Lower Granite Reservoir has not changed significantly over the past 85 years. Thus, any habitat degradation that may have occurred in the Columbia River estuary or plume is not the result of upstream development on the Snake River. Further, the flows required to make significant improvements of habitat in the estuary or plume are so large that any attempt to use Snake River augmentation water for that purpose will be just as futile as trying to restore pre-development water velocity through the hydropower system using Snake River flow augmentation. Snake River flow is a small portion of the total flow of the Columbia River at the estuary and the natural variation in flows between years dwarfs the contribution of the Snake River, let alone the much smaller volume of Upper Snake flow augmentation.

Table 2 illustrates that the flow of the Columbia River at the beginning of the estuary is at least 10 times greater than the flow of the Snake River at Weiser under both high and low flow conditions. It is impossible to try to restore the lower Columbia to pre-development conditions using augmentation from a source that provides less than 10 percent of the flow during the spring and summer.

Table 2 also compares minimum and maximum monthly discharges of the Columbia River at Beaver Army Terminal near Quincy, Oregon with the monthly discharge of the Snake River at Weiser during the same month. The Beaver Army Terminal gage is located at river mile 53.8 within the area of the river affected by tidal flow. Even though the gage record is short—10 years of records, some partial, from 1968 through 1997—it serves to show the wide variation in annual flow of the Columbia River. The variation in monthly flow from high (1997) to low (1992) years (18.5 MAF in June) is more than the average entire annual flow of the Snake River at Weiser (13.2 MAF).

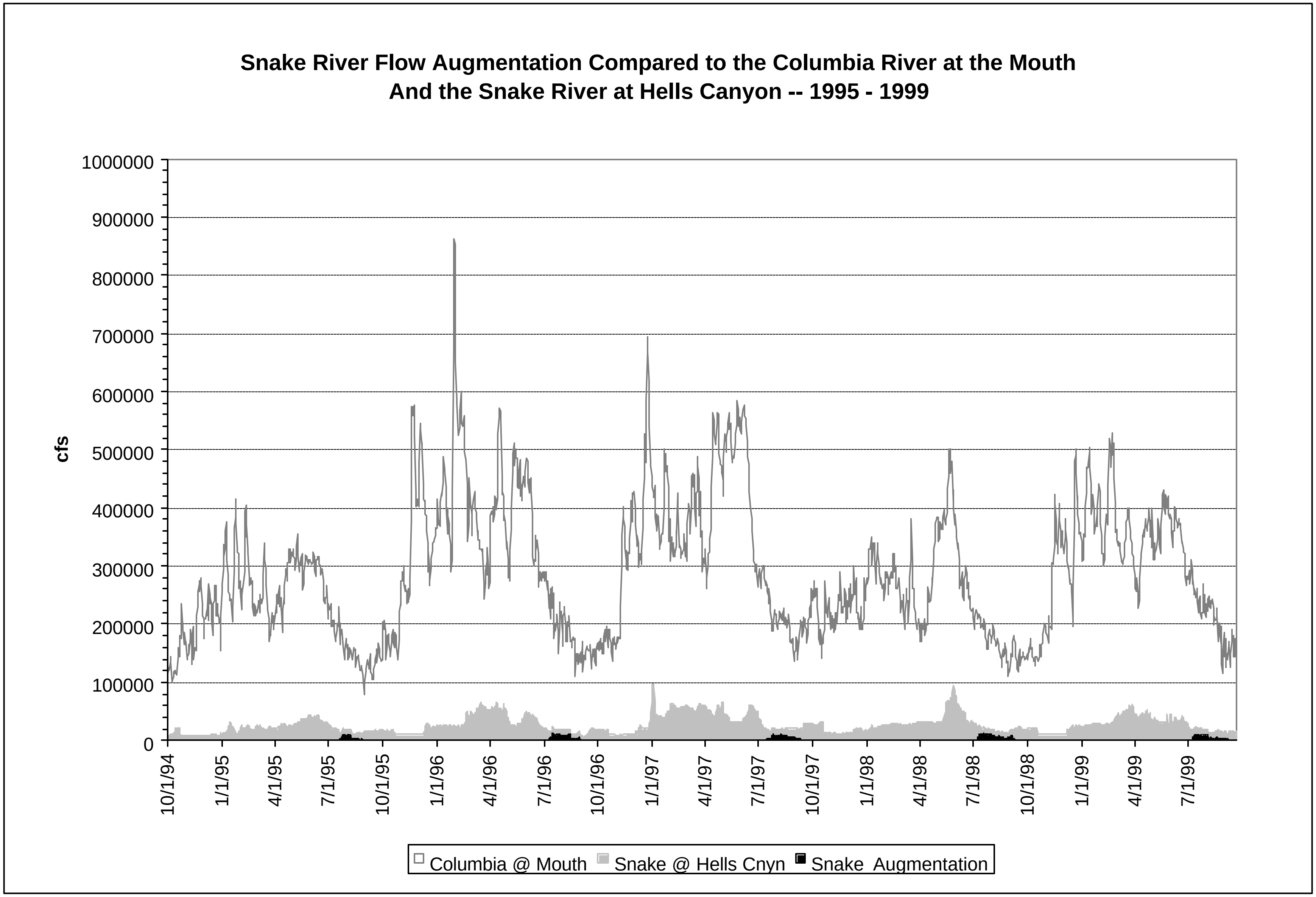
Table 2. Minimum and maximum monthly discharge of the Columbia River compared to Upper Snake River discharge in that month.

Month	Minimum Flow (MAF)			Maximum Flow (MAF)		
	Year	Lower Columbia River	Upper Snake River	Year	Lower Columbia River	Upper Snake River
April	1992	11.7	0.5	1969	24.2	2.3
May	1968	13.0	0.7	1997	31.2	2.5
June	1992	12.1	0.3	1997	30.6	2.9
July	1992	8.6	0.4	1997	17.2	1.1
August	1994	6.6	0.5	1997	12.8	0.9

Another way to consider the futility of using flow augmentation from the Upper Snake River is to compare the period of record average flow of the Columbia River at Beaver Army Terminal for July, a relatively low flow month during the period of flow objectives, to recent levels of Upper Snake River flow augmentation. The average monthly flow of the Columbia River for July at this location is 13.9 MAF for the period of record at the Beaver Army Terminal gage. If the entire 427,000 acre-feet of Upper Snake River flow augmentation were released in July, it would be only 3 percent of the average monthly July flow of the Columbia River at Beaver Army Terminal. Figure 10 shows Upper Snake River flow augmentation from 1995-1999 in relation to the flow of the Columbia River at the mouth.

Idaho water users believe that augmenting flows in order to significantly change the estuary or plume would be fruitless and an ineffective use of water resources. More cost-effective and biologically-beneficial approaches to recovery of listed species are discussed under *Recovery Options and Issues* near the end of this paper.

Figure 10. Snake River flow augmentation compared to the Columbia River at the mouth and the Snake River at Hells Canyon, 1995-1998.



Flow Targets

Table 3 contains the NMFS flow objectives for the Snake River at Lower Granite Dam. These flow objectives are set forth in the NMFS 2000 Biological Opinion on operation of the FCRPS (NMFS 2000f, p. 9-56).

Table 3. NMFS flow objectives, Snake River at Lower Granite Dam.

Spring (4/3 – 6/20)	85-100† kcfs
Summer (6/21 – 8/31)	50-55† kcfs

†Varies based on water volume forecasts.

Flow objectives at Lower Granite Dam are not necessary because current flows are approximately equal to historical flows in both amount and timing (Figures 5 and 6). Moreover, the flow targets have been set at an unreasonably high level that requires enormous volumes of flow augmentation from southern Idaho, especially in dry years—over 10 MAF would have been needed in 1977 and 1992, or nearly the total storage capacity of the largest 80 reservoirs in the Snake River basin (Dreher 1998, p. 13).

Flow and Turbidity

Idaho water users continue to evaluate the effect of flow augmentation on turbidity. Unfortunately, turbidity data on the Snake River is scarce. However, significant increases in turbidity as a result of flow augmentation are not expected. Most instances of high turbidity in the lower Snake River are the result of high tributary inflows due to storm events or snowmelt.

Flow and Temperature

Cold water has been released from Dworshak Reservoir in the Clearwater Basin to lower temperatures in the river for the benefit of salmon (NMFS 1999, pp. 29, 30). However, during low flow years (when temperatures are generally the highest), warm water released from the Upper Snake River counteracts the cooling effect of releases from Dworshak Reservoir (U.S. Army Corps of Engineers 1995, pp. 4-61). Recently, a new theory on the possible benefits of flow augmentation to modify river temperature has emerged:

> *"If modifications to Brownlee Dam were possible to change the temperature of the outflow from the dam to approximate more closely historic conditions, spawning, emergence, and rearing of fall chinook salmon might lead to more historical outmigration timing. Such changes in outmigration timing might substantially improve survival of Snake River juvenile fall chinook salmon as they would likely migrate downstream under much more favorable flow and water temperature conditions"* (NMFS 2000a, p. 58).

In the White Paper, however, there is no mention of temperature data, research, analysis, or any other information on the effects of water temperature on salmon.

The effect of the existing flow augmentation on the temperature downstream of Brownlee can be estimated.[12] The temperature in the Snake River below Hells Canyon (at River Mile 180)[13] is essentially determined by the sum of the temperatures of the Snake, Imnaha and Salmon rivers.

Figure 11 shows the predicted and observed temperatures at RM 180. Figure 12 shows that flow and temperature are not correlated downstream of Hells Canyon Dam at RM 246. Figure 13 shows that river temperature at Anatone and air temperature at Lewiston are linearly related. These three relationships demonstrate that Upper Snake flow augmentation does not significantly affect the temperature of the Snake River entering Lower Granite Reservoir.

[12] Additional information on the flow/temperature relationships described in the following paragraphs is provided in Anderson 2000.

[13] River Mile 180 (RM 180) is below the confluence of Snake, Imnaha and Salmon rivers, about 75 miles upstream from Lower Granite Dam (RM 106).

Figure 11. Observed temperature and predicted temperature at RM 180.

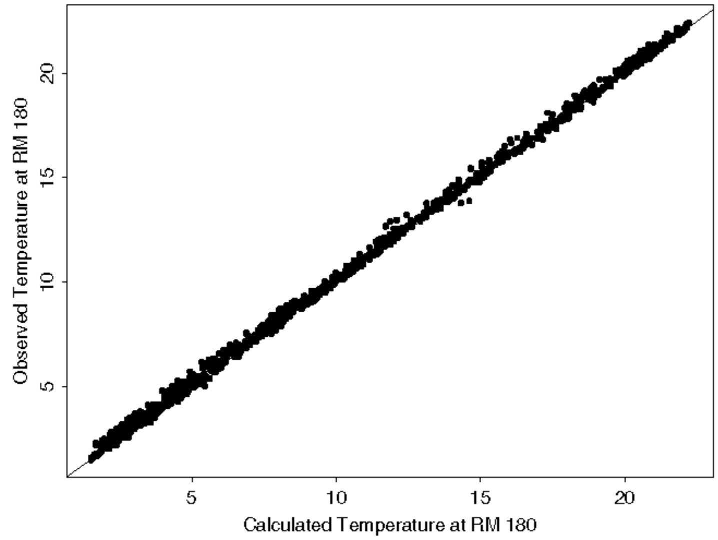


Figure 12. Flow is unrelated to temperature immediately below Hells Canyon dam. Data covers years 1991-1997.

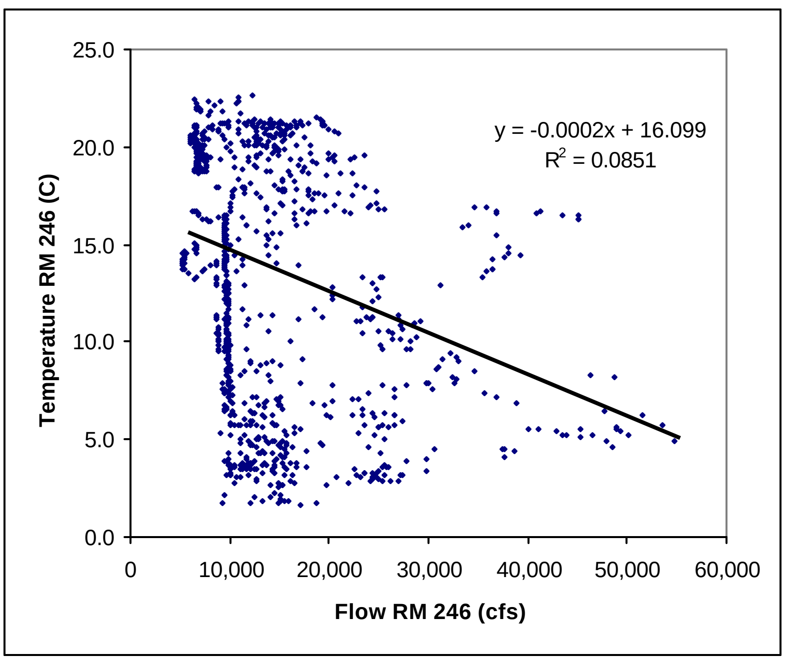
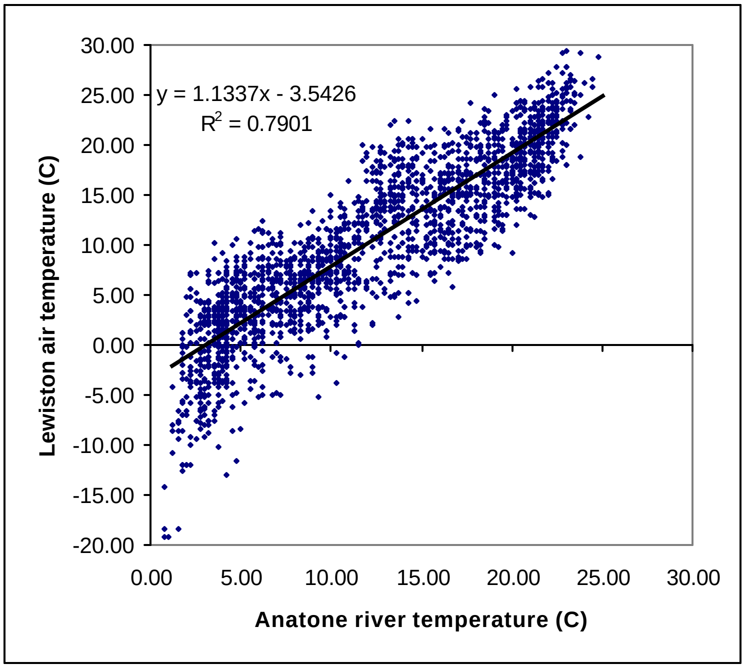


Figure 13. Air and water temperature are correlated. Data from years 1991 to 1997.



The effects of Upper Snake flow augmentation on downstream temperature at RM 180 can be calculated from the sum of the temperatures of the Snake, Imnaha and Salmon rivers weighted for different levels of flow augmentation. Figure 14 illustrates the difference in river temperatures at RM 180 with the additional 427 kaf. Note that Snake River flow augmentation has a small effect on the river temperature and that the augmentation typically causes river temperature to increase relative to the predicted temperature without augmentation. This graphically illustrates the problem with the assumption that flow augmentation is uniformly good for fish. In fact, the model indicates that Snake River temperatures would be reduced if Snake River flows were held constant rather than being augmented. For example, Figure 15 shows the predicted difference in river temperature caused by existing flow augmentation relative to temperatures with a constant Hells Canyon flow of 5000 cfs.

Figure 14. Temperature change resulting from the existing flow augmentation.

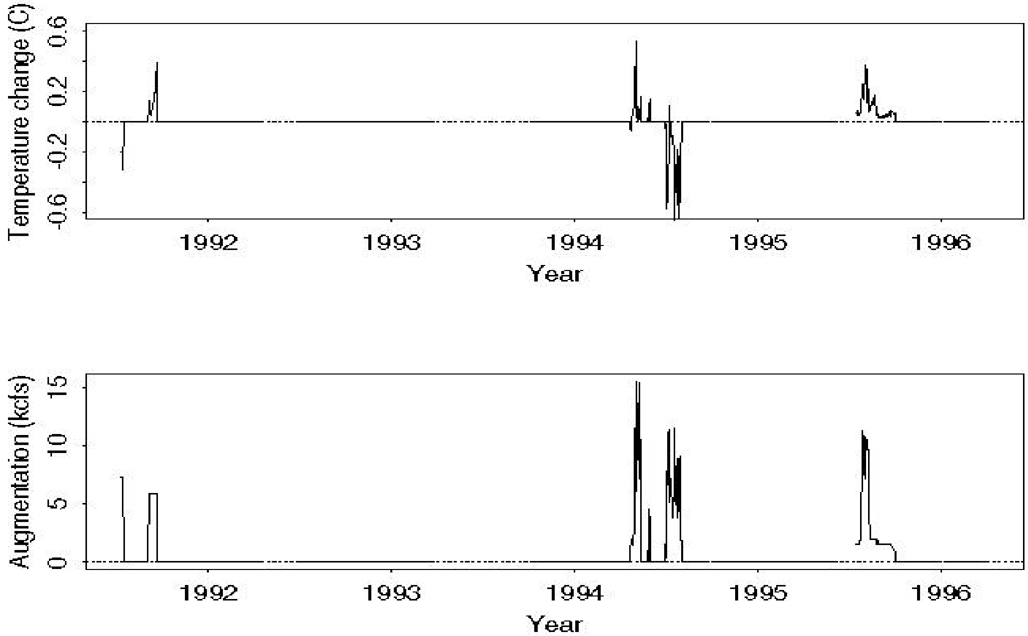
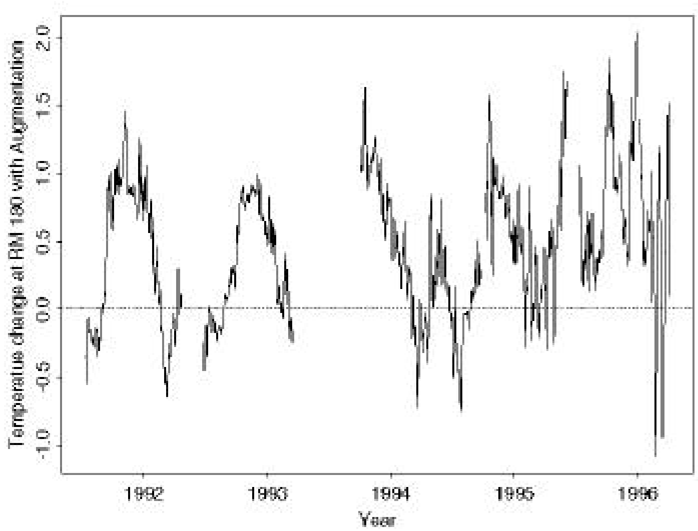


Figure 15. Temperature increase with the existing flow augmentation relative to temperature if Hells Canyon flows were limited to 5000 cfs.



Similarly, a study of the physical, chemical, and biological properties of Brownlee Reservoir supports the detrimental effect of summer flow augmentation from the Upper Snake under some conditions (Ebel and Koski 1968). The study found that Brownlee Reservoir stratifies in the summer with the warm upper layer extending down to or below the outlet works (Id. Figure 2). The study also evaluated the effect of the reservoir on Snake River flows above and below the Hells Canyon dams. Relative to Snake River inflows to Brownlee, temperature was higher and dissolved oxygen levels were lower below Oxbow from mid-summer through fall (Id. Figure 20). Thus, Upper Snake flow augmentation during mid-summer through fall releases warmer water with less oxygen, which can be detrimental to fish.

Estuary Timing

Flow augmentation also is being hypothesized as a way to change the timing of the arrival of smolts at the estuary to pre-dam conditions (NMFS 2000a, p. 58). The suggested use of flow is perplexing for two reasons. First, about 80 to 90 percent of Snake River chinook and steelhead passing through the estuary arrive through transportation. Transportation shortens the hydrosystem passage by two weeks for spring chinook and a month or more for fall chinook, resulting in estuary arrival times similar to the pre-dam conditions. Furthermore, under the existing hydrosystem, augmentation can only change the arrival time of the remaining 10 to 20 percent of in-river migrating fish by a few hours for spring chinook and a few days for fall chinook. Using water to speed arrival timing at the estuary is a gross misuse of water resources that would benefit only a small proportion of fish.

Recovery Options and Issues

Recovery efforts for listed species are mired in politics without clear, scientifically supported strategies for recovering the fish. Some scientists are advocating breaching the four lower Snake River dams in Washington as the only way to recover the listed Snake River species. Other scientists advocate barging more juvenile fish to the mouth of the Columbia as the best alternative to recover the species. Still other scientists believe adverse ocean conditions are responsible for the decline in salmon and steelhead populations and, when the ocean conditions recover, the fish will too. Harvest (fishing), predators (including terns and seals), loss of spawning habitat, and competition from hatchery-raised fish are other major reasons for the decline of wild salmon and steelhead. More than a dozen ongoing groups and processes are trying to address recovery for the listed species. There certainly is no consensus that flow augmentation should be a part of the recovery strategy for ESA-listed species (ISAB 1999, pp. 7, 12).

Ocean and Climate Conditions

Scientific evidence indicates that the northern Pacific Ocean was in a warm cycle from the mid 1970s to the mid 1990s. These warm conditions adversely affected salmon production in the Pacific Northwest. Currently the northern Pacific Ocean is cooling and salmon production is increasing (Hare and Mantua 1999, p. 1; JISAO/SMA Climate Impacts Group 1999, p. 14; Taylor 1997 and 1999; Casillas 1999; Espenson 2000). As a result, efforts to improve migration conditions in the Snake and Columbia Rivers over the past two decades may have been offset by poor ocean conditions. We may not know what is really working and what is not working. Kevin Friedland states the resulting issue succinctly: *"Management policy that is predicated on freshwater production trends and political trends and ignores decadal scale trends in ocean productivity is doomed to failure"* (Friedland 1999).

Management Options

Options for improving fish survival rates include habitat fertilization, harvest reduction, predator control, transportation improvements, hatchery improvements, dissolved gas abatement, and turbine improvements. These measures are discussed below.

Fertilization of Habitat

Recent research has demonstrated that the production of listed species could be dramatically improved through fertilization of habitat. As described in a recent edition of the NW Fishletter, the majority of the speakers at a recent conference on *Restoring Nutrients to Salmonid Ecosystems* reported that nutrient enrichment of spawning and rearing habitat has led to rapid rebuilding of salmon populations (NW Fishletter 2001). In addition to artificially fertilizing habitat through various means, one of the indirect methods that can be used to increase habitat fertility is to limit harvest so that more salmon escape to spawn and leave their carcasses in the streams. The direct benefits of limiting harvest are described in the next section.

Harvest Reduction

It is hard to think of a more perverse policy than to allow the harvest of substantial numbers of listed fish, particularly as they come upriver to spawn. The Idaho water users are not aware of any other species listed under the ESA where regular harvest within the boundaries of the United States is allowed. Adults that are killed on their way upstream have survived the life stages with the two largest components of mortality — incubation/rearing and ocean feeding — only to be taken a short time before spawning. The BiOp suggests that there is potential to improve survival of the listed species by further reductions in harvest (NMFS 2000f, p. 9-144). Idaho water users strongly support aggressive harvest strategies, options, and actions, especially with respect to fall chinook. Minimizing harvest is extremely cost effective relative to the enormous investments and tremendous uncertainties associated with the hydropower (flow augmentation or breaching), habitat, and hatchery options.

With respect to fisheries, Idaho water users strongly support pursuit of harvest reform through the use of selective fisheries, alternative methods and gear, and increasing harvest in terminal areas (pp. 9-145-150). We believe that these alternatives can provide Tribal fishing opportunities while still reducing the impact of harvest on listed species.

A substantial number of listed species continue to be harvested in the ocean and the mainstem Snake and Columbia Rivers. In-river harvest rates for Snake River spring/summer chinook have ranged from 3 to 8 percent in recent years (Marmorek et al. 1998, p. 14). Snake River fall chinook are subjected to heavy fishing pressure (NRC 1995, p. 82; Marmorek et al. 1998, p. 15). Table 4 shows combined ocean and river harvest rates of up to 75 percent for fall chinook (Peters et al. 1999, p. 71; see also NRC 1995, pp. 81, 82).

Table 4. Fall chinook exploitation (harvest).

Run Year	Mainstem (Columbia and Snake Rivers) Exploitation Rate		Ocean Exploitation Rate by Age				
	Jack	Adult	2	3	4	5	6
1986	0.055	0.469	0.015	0.106	0.170	0.169	0.303
1987	0.037	0.560	0.037	0.156	0.140	0.159	0.169
1988	0.046	0.524	0.027	0.060	0.288	0.172	0.159
1989	0.026	0.432	0.038	0.151	0.233	0.227	0.172
1990	0.028	0.452	0.042	0.059	0.271	0.252	0.227
1991	0.044	0.276	0.026	0.051	0.138	0.212	0.252
1992	0.051	0.166	0.020	0.095	0.242	0.204	0.212
1993	0.050	0.254	0.006	0.079	0.244	0.204	0.204
1994	0.033	0.155	0.015	0.014	0.229	0.204	0.204
1995	0.025	0.115	0.016	0.047	0.074	0.169	0.204
1996	0.039	0.171		0.046	0.000	0.158	0.169
Mean	0.039	0.325	0.024	0.079	0.184	0.194	0.207
Min	0.025	0.115	0.006	0.014	0.000	0.158	0.159
Max	0.055	0.560	0.042	0.156	0.288	0.252	0.303

The goals for improving hydrosystem survival are small and, as discussed previously in these comments, it is impossible to measure any incremental change that may be related to Upper Snake flow augmentation. However, the effect of harvest reduction can be clearly identified and the harvest reduction equivalent to the potential benefits of flow can be shown to be small and insignificant. To demonstrate the equivalence between small harvest reductions and large flow increases, we apply the approach developed by Norris (1995, 2000). Norris used the Pacific Salmon Commission Chinook Model to define equivalent harvest reduction policies for endangered Snake River fall chinook salmon. Because the stocks are harvested in a gauntlet of mixed-stock fisheries from Alaska to Oregon, the overall exploitation rate on Snake River fall chinook can be reduced by a variety of means, each of which has different economic consequences for the fisheries. Eight general types of policy alternatives were considered by Norris. Four policy options reduce harvest in specific geographic regions: the Alaska, British Columbia, or Washington and Oregon ocean fisheries, or the Columbia River fishery. Two policies reduce harvests in all regions in equal or scaled amounts; and two reduce harvests only in U.S. waters by equal or scaled amounts. Scaled policies reduce regional harvests in proportion to estimated regional catches of Snake River fall chinook during the period 1979 through 1993. Policies were deemed equivalent when the overall adult equivalent exploitation rate on the indicator stock (Lyon's Ferry Hatchery) was reduced by the same percentage. Equivalent policies were shown to be independent of assumptions about stock productivity.

Table 5 illustrates the tradeoffs between harvest and downstream survival by showing all possible solutions to reaching a specific escapement goal. In the Norris study, the goal was defined as 3,000 Snake River fall chinook spawners in year 2017. The model illustrates the change in harvest reduction to achieve the goal. For example, improving downstream survival 36 percent, reducing harvest by 60 percent, and improving upstream survival to 90 percent is equivalent to improving downstream survival by 360 percent, reducing harvest by 30 percent, and making no improvements in upstream survival.

Table 5. Downstream survival rates for various harvest rate reductions and prespawning survival rates required to achieve 3,000 spawners in year 2017.

Percent Harvest Reduction	Prespawn Survival = 0.6	Prespawn Survival = 0.7	Prespawn Survival = 0.8	Prespawn Survival = 0.9
0	1.034	0.870	0.745	0.650
10	0.847	0.712	0.609	0.531
20	0.699	0.587	0.503	0.438
30	0.582	0.489	0.418	0.364
40	0.488	0.410	0.350	0.305
50	0.412	0.346	0.295	0.257
60	0.350	0.294	0.251	0.218
70	0.299	0.251	0.214	0.186
80	0.257	0.215	0.184	0.160
90	0.222	0.186	0.159	0.138

The relative benefits of flow augmentation and harvest reduction can be evaluated using Table 5 and the estimates of life cycle survival improvements with flow augmentation. Although not statistically significant, a correlation of Snake River fall chinook SAR with year-to-year flow estimated that 0.5 MAF of Upper Snake flow augmentation would change survival by 1.6 percent (Anderson et al. 2000). In other words, total system survival would increase from 24.4 to 24.8 percent using the estimate for Snake River fall chinook in the Draft BiOp (NMFS 2000e). Using Table 5, and assuming the lowest pre-spawning survival of 60 percent (which requires the largest change in harvest) the goal of 3000 spawners can be achieved by reducing harvest 82.6 percent with flow augmentation or by reducing harvest by 83.7 percent without augmentation. The average ocean and river harvest rate during the period used in the Norris analysis are 36 percent and 50 percent. Thus, the harvest rates to meet the 3000 fish goal with flow augmentation are 6.4 percent for ocean harvest and 8.9 percent for river harvest. Without the 0.5 MAF of Upper Snake flow augmentation, the rates are 6.0 percent and 8.3 percent.

Under these worst-case conditions (optimistic estimates of the effect of flow augmentation on survival and pessimistic estimates on the number of spawners), a further change in harvest rate of 0.5 percent is equivalent to the effect of the Upper Snake River flow augmentation. It is important to note these calculations assume that a flow survival correlation between year-to-year flows will become statistically significant and if so, the same increases in survival can be achieved using flow augmentation within a year. It also assumes that the statistically insignificant flow survival relationship is strictly due to the water flowing down the river when the fish are migrating. In actuality, many environmental factors are correlated with seasonal flow including ocean productivity and the over wintering conditions of the fish prior to their migration. Therefore, the actual harvest reduction needed to achieve the theoretical effect of flow augmentation is likely to be less than one-half of one percent.

Harvest reforms can provide significant benefit to the listed species, especially Snake River fall chinook. Reducing harvest rates will improve the probability of recovery by 100% or more (Peters et al. 1999, pp. 197, 198).

Predator Control

An enormous number of salmonid smolts are consumed each year by predators. Predators include other fish, marine animals, and birds. Northern pikeminnow (formerly northern squawfish) alone consume an estimated 16.4 million smolts annually (NMFS 2000b, p. 14). Since 1990, the Predator Control Program has reduced predation by northern pikeminnow by an estimated 13 percent (Id. p. 15). Additional reductions in pikeminnow predation are "*probable*" (Id.).

Smallmouth bass, walleye, channel catfish, Pacific lamprey, yellow perch, largemouth bass, northern pike, and bull trout also prey on salmonid smolts (Id. pp. 18-31). Consumption of smolts by these fish species is significant but has not been studied as thoroughly as pikeminnow predation (Id.). The annual loss from these other fish predators is estimated to be in the hundreds of thousands or more (Id.). However, a predator control program for these species has not been implemented (Id. pp. 34, 35).

Avian predators such as Caspian terns, double-crested cormorants, and gulls consume millions of smolts each year (NMFS 2000b, pp. 37-42). It is estimated that 10 to 30% (100,000 to 600,000) of smolts reaching the Columbia River estuary are consumed by predatory birds (Id. p. 39).

Although the total impact has not been determined yet, marine mammals injure and consume large numbers of salmon and steelhead (Id. pp 43-46). Importantly, marine mammal predation occurs on adults as well as juveniles (Id.). Protection of adults returning to spawn — fish that have survived the gauntlet of mortality in previous life stages — is obviously important to recovery of threatened and endangered populations.

Transportation Improvements

Many studies have shown that the smolt-to-adult return of transported fish is higher than the return of in-river migrants (NMFS 2000c). Although continued decline in fish populations raises questions about the effectiveness of transportation, further research is warranted (Id.). Moreover, there are opportunities to further improve transportation success such as with the use of towed net pens (McNeil et al. 1991). Transportation has the potential to be one of the most cost-effective salmon and steelhead recovery measures.

Hatchery Improvements

There appears to be a consensus that hatcheries have negatively affected wild salmonid populations (Brannon et al. 1999, p. 11; NRC 1995, p. 273). A number of recommendations and management alternatives have been developed that would improve hatchery programs (Id. pp. 13-21; Federal Caucus 1999, pp. 6, 7). Idaho water users support the aggressive hatchery changes suggested by the Federal Caucus including expansion of hatchery conservation programs while reducing mitigation programs.

Dam Passage

For both juveniles and adults, NMFS finds that continued increased passage survival can be gained from improvements in bypass systems, gas abatement, spill, and turbine operation (NMFS 2000d, pp. 82-84). A number of these improvements are on-going (Id.).

Spill is often problematic given associated issues involving dissolved gas increases, direct mortality from spill, lack of a way to measure success, and potentially reduced transport effectiveness. Spill below a total dissolved gas (TDG) cap of 110% may be beneficial for juvenile fish but there have been water quality variances issued for up to 115% on a daily average and 120% on an instantaneous basis. Above 110%, gas levels are dangerously high because unscheduled inflows may occur, which force higher spills, higher TDG levels, and the death of fish through gas bubble disease. The impact of high TDG on adult fish is even greater since adults are more susceptible to the effects of TDG than juvenile fish. In addition to gas bubble mortality, spills at higher levels can produce direct mortality at the dams. For example, at The Dalles, higher survivals are obtained with lower spills. Additionally, spill is largely of speculative benefit because the survival of spilled fish cannot be measured since they are not detected at dams. Finally, current proposals by NMFS to spill up to a TDG maximum level of 115-120% at transport dams (NMFS 2000f, p. 9-120) will reduce the number of fish transported and thus, will decrease overall passage survival.

Economic and Social Impacts of Upper Snake Flow Augmentation

Although the magnitude of economic and social impacts reported by the Bureau of Reclamation (Reclamation) was a major reason for elimination of the MAF alternative from the Corps' FR/EIS, Idaho water users believe that the impacts of providing an additional 1 MAF of flow augmentation to Lower Granite Reservoir will actually be much greater than estimated by Reclamation.

Background of MAF Proposal

Various entities requested flow augmentation from the Upper Snake River as an "experiment" or an "interim" measure. The Northwest Power Planning Council suggested flow augmentation as an "experiment" to test the hypothesis that there is a "relationship between spring and summer flow, velocity and fish survival" in an adaptive management framework (NPPC 1994, p. 5-13). The National Marine Fisheries Service called for "interim target flows" — and thus, flow augmentation — on the basis of a finding that "… a general relationship of increasing survival of Columbia River basin salmon and steelhead with increasing flow is reasonable" (NMFS 1995, pp. 1, 2). Despite the lack of scientific evidence or legal basis for flow augmentation, Idaho water users acquiesced in the experimental Program and helped pass state legislation to authorize the use of water for flow augmentation. Several years of research were conducted to assess the effects of flow on the survival of listed species. As discussed in the previous section, no significant benefit from Upper Snake River flow augmentation is evident from research. Thus, the basis for the NMFS interim target flows has been dispelled.

Reclamation Analysis

Reclamation's study of the MAF proposal was developed as part of the Lower Snake River Juvenile Salmon Migration Study (U.S. Army Corps of Engineers et al. 1999). At the request of the Corps of Engineers, Reclamation analyzed the effects of supplying an additional 1 MAF of flow augmentation to Lower Granite Reservoir (Bureau of Reclamation 1999). This augmentation is in addition to the 427,000 AF/yr that has been provided from the Upper Snake River since 1993 (Id. p. 5-9). Depending on whether storage reservoirs are operated to minimize the impact on irrigation (1427i) or recreation (1427r), Reclamation estimates the impacts shown in Table 6.

Table 6. Reclamation Impacts, Million Acre Feet Study.

National Effects	1427i	1427r
Decrease in irrigated acres in average water-year	243,000	360,000
Decrease in irrigated acres in dry water-year	376,000	643,000
Decrease in value of production in average water-year	$90,204,000	$136,433,000
Decrease in value of production in dry water-year	$141,202,000	$243,737,000
Loss of proprietors income and other property income (annual)	$46,691,000	$81,357,000
Annual water acquisition cost		
Low estimate	$10,414,000	$31,128,000
High estimate	$31,243,000	$87,157,000
Regional Effects	1427i	1427r
Employment - annual jobs lost	2,543	3,612
Annual income lost	$44,700,000	$51,976,000
Annual sales lost	$95,200,000	$130,400,000

Additional direct costs would be incurred by hydropower, recreation, and municipal interests. Although Reclamation determined that detailed estimates of the economic impact to these sectors are difficult to make due to uncertainties in the location, frequency and amount of water shortage from flow augmentation, indications are that the direct net costs may be tens of millions of dollars per year (Bureau of Reclamation 1999, pp. 6-27 to 6-52, 9-4). Moreover, as with irrigation, Reclamation found that there would be additional secondary impacts resulting from the costs incurred in these sectors.

Water User Analysis of MAF Proposal

Questions about the accuracy and reliability of Reclamation's model led the Idaho water users to seek an independent analysis using the Snake River Planning Model developed by the Idaho Department of Water Resources. Idaho water users commissioned Brockway Engineering to evaluate the Reclamation MAF study and to independently model the hydrologic impacts of flow augmentation using 1.427 MAF.[14] The report prepared by Brockway Engineering, *Evaluation of Flow Augmentation*

[14] The senior investigator for the Brockway report is Charles E. Brockway, Ph.D., P.E. Dr. Brockway served for 32 years on the faculty of the University of Idaho at the Water Resources Research Institute specializing in hydrologic modeling and irrigation. Charles G. Brockway, Ph.D., P.E., specializing in modeling and statistical analysis, completed major portions of this research and report.

Proposals on the Snake River above Lower Granite Dam (Brockway) (IWU 2000b, Appendix 3).

Brockway Engineering found that Reclamation's study overestimates the ability to meet the goal of providing 1.427 MAF or the NMFS target flows, whichever is less. Average contents of the many large reservoirs used for flow augmentation will decrease by 9 to 36%. As discussed in Brockway, the "best" case results with respect to irrigation impacts are similar to the worst case scenario (1427r) in the Reclamation study. On average, attempts to minimize recreation impacts (Case 5) cause even more severe shortages to irrigation. Table 7 summarizes the results.

Table 7. Water User Analysis ¾ Million Acre Feet Study.

Effect	Case 3*	Case 4	Case 5
Decrease in irrigated acres in average water year	282,100	284,500	314,010
Decrease in irrigated acres in dry water year	574,000	696,200	618,700
Average Reduction in Content of Major Reservoirs			
Jackson Lake	26.4%	26.9%	14.2%
Palisades Reservoir	31.3%	32.0%	28.5%
American Falls Reservoir	21.1%	21.5%	15.1%
Anderson Ranch Reservoir	35.1%	36.1%	31.8%
Arrowrock Reservoir	23.8%	24.5%	8.7%
Lucky Peak Reservoir	26.9%	27.6%	21.9%
Cascade Reservoir	33.1%	34.0%	30.8%

*Case 3 = Flow demand at Lower Granite with current irrigation priorities (existing conditions).
Case 4 = Flow demand at Lower Granite with increased irrigation priorities.
Case 5 = Flow demand at Lower Granite with reduced irrigation priorities.

Economic impacts correspond directly to the magnitude of hydrologic impacts. Using Reclamation's estimates of economic impacts per acre, the decreases in value of agricultural production based on the water user analysis are shown in Table 8.

Table 8. Water user estimates of agricultural production impacts.

	Case 3	Case 4	Case 5
Decrease in value of production in average water-year	$105,800,000	$106,700,000	$117,800,000
Decrease in value of production in dry water-year	$215,300,000	$261,100,000	$232,000,000

Based on Table 8, the present value (8%, 100 years) of the average annual loss in agricultural production exceeds $1.2 billion. Additionally, there would be large indirect or secondary impacts as the change in agricultural production ripples through the state's economy. The multiplier to estimate these indirect impacts in other sectors of Idaho's economy ranges from 2 to 2.5 or more (Olsen 1998b; Aillery 1996). Thus, the annual impact on all sectors of the Idaho economy could exceed $650 million. The impact also can be expressed in terms of elimination of thousands of farms or tens of thousands of jobs in agriculture, food processing, and related sectors of the economy. Also, local tax revenues in agricultural areas would be severely reduced.

Drying up hundreds of thousands of acres with the MAF proposal also would cause numerous other impacts that would result in costs being borne by third parties or compensation being required. Reclamation identifies a number of impacts including, but not limited to:

> "*(1) water right identification, change of use, and monitoring;*
> *(2) negotiation, contracting, and legal costs for purchases and leases of water;*
> *(3) revegetation costs for lands no longer irrigated;*
> *(4) in lieu irrigation district operation and maintenance charges and property taxes;*
> *(5) erosion, weed, and insect control on idled lands;*
> *(6) environmental compliance requirements prior to water sale and lease;*
> *(7) mitigation costs for environmental impacts;* [and]
> *(8) new water measurement/control facilities."*
> (Bureau of Reclamation 1999, p. 6-25).

Impacts on Recreation, Resident Fish and Wildlife, and Other Non-Agricultural Values

Reclamation's MAF study qualitatively evaluated a number of impacts in addition to changes in agricultural production. Reclamation identified impacts to water quality, resident fish populations, recreation, and social well being (Bureau of Reclamation 1999). As discussed below, the impacts to water quality, fish and recreation are likely to be greater than described by Reclamation.

Due to time limitations, Reclamation's study only included some reservoirs and river reaches rather than the entire Upper Snake system (Id. p. 7-87).[15] Nevertheless, Reclamation found significant adverse effects to recreation from flow augmentation (Id. Summary — 12, 13). Given the significantly lower average content of major reservoirs under the water users analysis as shown in Table 9, Reclamation recreation impacts are greatly understated. Similarly, Reclamation's assessments of river-based losses in recreation (especially in the Boise River) are likely underestimated due to more variable flow (Brockway, p. 48).

Resident fish and water quality impacts are closely related to reservoir and stream levels (Bureau of Reclamation 1999, Summary — 9). Thus, the impacts to these resources would follow the same pattern as discussed above for recreation, i.e., the adverse effects would be greater than Reclamation's estimates.

Table 9. Average Reduction in Content of Major Reservoirs.

Effect	Water User Analysis			Reclamation's Analysis	
	Case 3*	Case 4	Case 5	1427i	1427r
Jackson Lake	26.4%	26.9%	14.2%	8%	2%
Palisades Reservoir	31.3%	32.0%	28.5%	1%	(2%)**
American Falls Reservoir	21.1%	21.5%	15.1%	14%	3%
Anderson Ranch Reservoir	35.1%	36.1%	31.8%	12%	4%
Arrowrock Reservoir	23.8%	24.5%	8.7%	34%	(21%)
Lucky Peak Reservoir	26.9%	27.6%	21.9%	13%	(5%)
Cascade Reservoir	33.1%	34.0%	30.8%	20%	4%

*Case 3 = Flow demand at Lower Granite with current irrigation priorities (existing conditions).
Case 4 = Flow demand at Lower Granite with increased irrigation priorities.
Case 5 = Flow demand at Lower Granite with reduced irrigation priorities.
**(2%) means that Reclamation's study reports an <u>increase</u> in average reservoir content, not a reduction.

In addition to the qualitative impacts on non-agricultural resources, direct costs would be incurred by recreation and municipal interests. Although detailed estimates of the direct costs to these sectors are difficult to make due to uncertainties in the location, frequency and amount of water shortage from flow augmentation, indications are that the direct net costs may be tens of millions of dollars per year (Bureau of Reclamation 1999,

[15] Reclamation states that similar results are expected for other reservoirs and stream reaches affected by flow augmentation.

pp. 6-27 to 6-52, 9-4; Sommers 1992). Moreover, as with irrigation, there would be additional secondary impacts resulting from the costs incurred in these sectors.

Conclusions

Idaho water users are caught between conflicting federal policies. For over 100 years, Idaho has built its economy on water development, fostered and encouraged by the federal government. Federal agencies and various flow augmentation advocates continue to seek large blocks of Idaho water to increase downstream flows. The augmented flows are intended to help fish passage problems at downstream federal dams. Idaho water users oppose continued Upper Snake River flow augmentation because there is no evidence that the release of enormous volumes of water has significantly benefited Snake River spring and summer chinook, steelhead, or sockeye populations or contributed to their survival. Development of water resources in the Upper Snake River basin did not cause the decline of fish populations and has not resulted in the destruction or adverse modification of critical habitat. Continuing to reduce Upper Snake River water uses to provide flow augmentation will not reverse the fish population decline, recover the populations, or mitigate the adverse modification of critical habitat caused by activities in the lower Snake and Columbia Rivers. We believe that successful recovery of salmon runs must reflect a pragmatic assessment of the hydrologic, economic, biological, and political realities of Idaho and the Pacific Northwest.

References Cited

Aillery, Marcel P. et al. 1996. Salmon Recovery in the Pacific Northwest: A Summary of Agricultural and Other Economic Effects. Agriculture Information Bulletin No. 699. USDA, Economic Research Service. Herndon, Virginia.

Anderson, J.J. 2000. Heat Budget of Water Flowing through Hells Canyon and the Effect of Flow Augmentation on Snake River Water Temperature. University of Washington, Seattle, WA. October 13.

Anderson, J.J, R.A. Hinrichsen and C. Van Holmes. 2000. Effects of Flow Augmentation on Snake River Fall Chinook, http://www.cqs.washington.edu/papers/jim/flowaug_fch.pdf> December 2000.

Anderson, J. J. 2001. Testimony of James J. Anderson, Associate Professor, School of Aquatic and Fishery Sciences, University of Washington before the Subcommittee on Water and Power of the U.S. House of Representatives Committee on Resources. May 19, 2001. Tacoma, WA.

Arrington, L.J. 1986. Irrigation in the Snake River Valley, A Historical Overview. Idaho Yesterdays, Spring/Summer 1986, pp. 3-11.

BPA (Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers). 1999. Multi-Species Biological Assessment of the Federal Columbia River Power System. Submitted to the National Marine Fisheries Service and U.S. Fish and Wildlife Service. December 21, 1999.

Brannon, Ernest L. et al. 1999. Review of Artificial Production of Anadromous and Resident Fish in the Columbia River Basin, Part I: A Scientific Basis for Columbia River Production Program, Northwest Power Planning Council.

Casillas, Ed. 1999. Transcript of Presentation on Ocean Impacts on Anadromous Fish Populations, Northwest Power Planning Council Meeting, April 7, 1999.

Connor, W.P., et al. 1998. Early life history and survival of Snake River natural subyearling fall chinook salmon in 1996. *In* T.G. Williams and T.C. Bjornn. Fall Chinook Salmon Survival and Supplementation Studies in the Snake River and Lower Snake River Reservoirs, 1996. Bonneville Power Admin. Proj. 93-029. Feb. 1998.

Connor, W.P., R. K. Steinhorst and H.L. Burge. 2000. Forecasting Survival and Passage of Migratory Juvenile Salmonids. *North American Journal of Fisheries Management* 20:651-660, 2000.

Dreher, Karl J. 1998. Competing for the Mighty Columbia River—Past, Present and Future: The Role of Interstate Allocation. Idaho Department of Water Resources, Boise, Idaho. April 30-May 1, 1998.

Ebel, Wesley J. and Charles H. Koski. 1968. Physical and Chemical Limnology of Brownlee Reservoir, 1962-64. Fishery Bulletin: Vol. 67, No. 2, pp. 295-335. December 1968.

Espenson, Barry. 2000. "Tribes Get Spring Chinook Commercial Fishery." The Columbia Basin Bulletin, pp. 2-4, May 5, 2000. www.intercom.ucinet.com, May 5, 2000.

Federal Caucus. 1999. 4-H Paper: Conservation of Columbia Basin Fish Building a Conceptual Recovery Plan with the Four Hs. Working Paper, November 1999.

Friedland, Kevin. 1999. Can J. Fish Aquat Sci 55 (suppl 1): 119-13.

Helsel, D.R. and R.M. Hirsch. 1993. Statistical Methods in Water Resources. Paperback edition (Amsterdam, The Netherlands. Pp. 266-275, 326-328.

Hare, Steven and Nathan J. Mantua. 1999. Empirical Indicators of Climate Variability and Ecosystem Response Since 1965. October 18, 1999. <http://www.iphc.washington.edu/Staff/hare/html…/abst_ei.htm.

IDFG (Idaho Department of Fish and Game). 2001. Review of Idaho Water Users Supplemental Comments (February 27, 2001): Upper Snake Flow Augmentation for Spring/Summer Chinook and Steelhead. April 25, 2001.

IWRB (Idaho Water Resource Board). 1996. Idaho State Water Plan. December 1996 (Ratified by the Idaho Legislature March 1997). Boise, Idaho.

IWU (Idaho Water Users). 2000a. Comments by Idaho Water Users on the Draft All-H Paper by the Federal Caucus. March 16, 2000.

IWU (Idaho Water Users). 2000b. Idaho Water User Recommendations on Amendments to the Columbia River Basin Fish and Wildlife Program. May 12, 2000.

IWUA (Idaho Water Users Association). 1999. Idaho Water Watch-Issue No. 28. March 12, 1999.

ISAB (Independent Scientific Advisory Board). 1999. Looking for Common Ground: Comparison of Recent Reports Pertaining to Salmon Recovery in the Columbia River Basin. ISAB Report 99-3, February 1, 1999.

JSIAO/SMA Climate Impacts Group. 1999. Impacts of Climate Variability and Change, Pacific Northwest. A report of the Pacific Northwest Regional Assessment Group for the U.S. Global change Research Program. University of Washington, Seattle. November 1999.

Marmorek, D.R. et al. (eds.). 1998. PATH Final Report for Fiscal Year 1998. ESSA Technologies Ltd., Vancouver, BC.

McNeil, W.J., R. Gowan, and R. Severson. 1991. Offshore Release of Salmon Smolts. Am. Fish. Soc. Symp. 10:548-553.

Muir, W.D., S.G. Smith, E.E. Hockersmith, M.B. Eppard, W.P. Connor, T. Anderson, and B.D. Arnsberg. 1999. Fall Chinook Salmon Survival and Supplementation Studies in the Snake River and Lower Snake River Reservoirs, 1997. Report No. DOE/BP-10891-8, Bonneville Power Administration, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1995. Basis for Flow Objectives for Operation of the Federal Columbia River Power System. Seattle, WA.

NMFS. 1999. An Assessment of Lower Snake River Hydrosystem Alternatives on Survival and Recovery of Snake River Salmonids, Appendix _ to the U.S. Army Corps of Engineers' Lower Snake River Juvenile Salmonid Migration Feasibility Study. April 14, 1999.

NMFS. 2000a. White Paper: Salmonid Travel Time and Survival Related to Flow Management in the Columbia River Basin. Northwest Fisheries Science Center, Seattle, Washington. March 2000.

NMFS. 2000b. White Paper: Predation on Salmonids Relative to the Federal Columbia River Power System. Northwest Fisheries Science Center, Seattle, Washington. March 2000.

NMFS. 2000c. White Paper: Summary of Research Related to Transportation of Juvenile Anadromous Salmonids Around Snake and Columbia River Dams. Northwest Fisheries Science Center, Seattle, Washington. April 2000.

NMFS. 2000d. White Paper: Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams. Northwest Fisheries Science Center, Seattle, Washington. April 2000.

NMFS. 2000e. Biological Opinion. Appendix C. August 30 Draft. <http://www.nwr.noaa.gov/1hydrop/hydroweb/docs/2000/appendc.pdf>.

NMFS. 2000f. Biological Opinion on the Reinitiation of Consultation on Operation of the Federal Columbia Rive Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. December 21, 2000.

NMFS. 2001. Biological Opinion: Bureau of Reclamation Operations and Maintenance of its Projects in the Snake River Basin Above Lower Granite Reservoir From Date Issued Through March 2002. May 2, 2001.

Norris J. G. 2000. Defining Equivalent Harvest Reduction Policies for Endangered Salmon Stocks. Sustainable Fisheries Management: Pacific Salmon. Editor Knudsen et al.

Norris, J. G. 1995. A Simple Spreadsheet Model for Evaluating Recovery Strategies for Snake River Fall Chinook Salmon Fisheries Research Institute, University of Washington, Seattle, WA http://www.cbr.washington.edu/papers/global.pdf)

NPPC (Northwest Power Planning Council). 1994. Columbia River Basin Fish and Wildlife Program. Portland, OR.

NRC (National Research Council). 1995. Upstream: Salmon and Society in the Pacific Northwest. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, Board on Environmental Studies and Toxicology, Commission on Life Sciences.

NW Fishletter. 2001. NW Fishletter No. 125. <http://www.newsdata.com/enernet/fishletter/index.html? June 5, 2001.

Olsen, Darryll et al. 1998a. The Columbia-Snake River Flow Targets/Augmentation Program: A White Paper Review with Recommendations for Decision Makers. Pacific Northwest Project. Kennewick, Washington.

Olsen, Darryll. 1998b. Western Irrigation Economic Benefits Review: Irrigated Agriculture's Role for the 21st Century. The Pacific Northwest Project. Kennewick, Washington.

Peters, C.N. et al. 1999. PATH Decision Analysis Report for Snake River Fall Chinook. ESSA Technologies Ltd., Vancouver, BC.

Sims, C.W. and F. Ossiander. 1981. Migrations of juvenile chinook salmon and steelhead in the Snake River, from 1973 to 1979, a research summary. Report (Contract DACW68-78-C-0038) from National Marine Fisheries Service to U.S. Army Corps of Engineers, Portland, Oregon.

Sommers, Craig L. 1992. Upper Snake River Economic Impacts: NPPC Phase Two Amendments. *In:* Comments on the Phase Three Working Draft. Northwest Power Planning Council. May 28, 1992.

Steward, C. 1994. Assessment of the Flow/Survival Relationship Obtained by Sims and Ossiander (1981) for the Snake River Spring/Summer Chinook Salmon Smolts, Final Report. Prepared for the Bonneville Power Administration, Portland, Oregon.

Taylor, George and Chad Southards. 1997. Long-term Climate Trends and Salmon Population. http://ocs.oce.orst.edu/reports/climate_fish.html. April 1997.

Taylor, George H. 1999. Long-Term Climate and Ocean Trends and Salmon Populations in the Pacific Northwest. *In* Ocean Conditions and the Management of Columbia River Salmon. Proceedings of a Symposium, July 1, 1999, Portland, Oregon. December 23, 1999. 61 pp. http://www.nwppc.org/ocean/ocean_1.htm.

U.S. Army Corps of Engineers. 1995. Columbia River System Operation Review Final Environmental Impact Statement. North Pacific Division.

U.S. Army Corps of Engineers, Bureau of Reclamation, Bonneville Power Administration, and the Environmental Protection Agency. 1999. Draft Feasibility Report/Environmental Impact Statement, Lower Snake River Juvenile Salmon Migration Feasibility Study. December 1999.

U.S. Bureau of Reclamation. 1998. Bureau of Reclamation Operations and Maintenance in the Snake River Basin Above Lower Granite Reservoir — Biological Assessment. Pacific Northwest Region, Boise, Idaho. February 1998.

U.S. Bureau of Reclamation. 1999. Snake River Flow Augmentation Impact Analysis Appendix. United States Department of Interior, Bureau of Reclamation, prepared for the U.S. Army Corps of Engineers Lower Snake River Juvenile Salmon Migration Feasibility Study and Environmental Impact Statement. Boise, Idaho.

Williams J. and E. Matthews. 1995. A Review of the Flow/Survival Relationships for Juvenile Salmonids in the Columbia River Basin. NMFS, Northwest Fisheries Science Center, Seattle, Washington.