

June 8, 2004

MEMO FOR: Hydro files

FROM: FCRPS Branch staff

SUBJECT: Analysis of Summer Spill Impacts on Listed Wild SR Fall Chinook Salmon Compared to Brownlee Flow Augmentation Offset for Summer Spill Proposal

The purpose of this memo is to describe an analytical approach and assumptions used to evaluate both: a) the biological effects of curtailing summer spill in 2004 at Ice Harbor and John Day dams on August 22 and at The Dalles and Bonneville dams on the lower Columbia River on August 1; and b) the potential biological benefit of an additional 100 Kaf flow augmentation during July from Idaho Power Company's Brownlee Reservoir on the Snake River.

Summer Spill Analysis of Impacts on Listed Wild SR Fall Chinook Salmon

Background and Methods: The first part of the analysis considers the impact of two FCRPS summer operational scenarios, a) the 2000 FCRPS BiOp spill program and b) the Corps of Engineers' and Bonneville Power Administration's proposal to curtail summer fish spill at Ice Harbor and John Day dams on August 22 and at The Dalles and Bonneville dams on the Lower Columbia River on August 1.¹ For this analysis we needed to consider the population of listed Snake River fall chinook that would be affected, the migration timing or distribution of those fish, and the relative impact in terms of smolt survival to below Bonneville Dam. The methods for determining each component of the analysis are explained below.

Starting Listed Fish Population: The estimated number of fish affected by this proposal is based on NOAA-NWFSC's 2003 population estimate for outmigrating wild Snake River fall chinook at the face of Lower Granite Dam (March 20, 2003, J. Ferguson memo):

Listed Wild Fish	1,051,615
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Listed Fish Distribution: Smolt passage distribution is an important parameter in this analysis to enable an estimate of the number of juvenile fish affected by the Action Agencies' summer spill proposal. The overall impact of different spill operational alternatives is sensitive to outmigration distribution. Therefore, NOAA Fisheries decided to use a range of possible migration shapes based on the range of observed listed SR fall chinook outmigrations after reviewing historical fish passage data from DART. Early, middle and late migration estimates of the percent of listed fish passing in each period of operation are listed in Table 1 below. It was determined that we are unable to predict with any certainty, ahead of the summer fish passage period, whether it will be an early,

¹ Planned fish passage research on alternative spill operations at Ice Harbor Dam will occur until July 15th. Planned fish passage research on alternative spill operations at Bonneville Dam will also occur during the month of July.

middle or late migration year for SR fall chinook this summer. Thus, all three migration conditions are included in the impact analysis, with 2003 migration data for SR fall chinook representing an early migration year, 1996 data reflecting a typical migration year, and 1995 data for a late migration year.

Table 1.

Period of Operation	Early Migration Year (2003)	Middle Migration Year (1996)	Late Migration Year (1995)
July 19 to Aug. 18 PIT-tag data @ LMN	24.4%	56.1%	62.1%
July 19 - August 7 PIT-tag data @ LMN to represent Aug. 1-21 spill	19.9%	31.7%	38.3%
Aug. 8-18 PIT-tag data @ LMN to represent Aug. 22-31 no spill	4.5%	24.4%	23.8%

All distributions were based on PIT-tag passage data from DART. The July 19 to August 18 fish migration distributions were based on PIT-tag data at Lower Monumental Dam (LMN) and an average fish travel time from that project to The Dalles Dam (TDA) of 13 days. So a juvenile fish leaving LMN on July 19 could be expected to arrive at TDA Dam in the lower Columbia River on August 1, while a fish leaving LMN on August 18 would be expected to arrive at TDA on August 31. Thus, for early, middle and late migrations, approximately 24%, 56% and 62% of the total summer juvenile SR fall chinook migration, respectively, could be expected to be migrating through the lower Columbia River during the month of August (Table 1).

However, in the latest spill proposal from the Action Agencies, summer spill would continue through August 21 at Ice Harbor and John Day dams, while spill would be curtailed at The Dalles and Bonneville dams after July 31, i.e., during all of August. So the July 19 - August 7 row in Table 1 illustrates the early, middle and late juvenile fish distributions for those fish affected by: a) BiOp spill conditions at Ice Harbor and John Day dams through August 21; and b) a no spill condition at The Dalles and Bonneville dams. Similarly, the August 8-18 row of fish distributions in Table 1 shows the early, middle and late migrations for fish affected by a no spill condition at any of the four FCRPS dams during the August 22-31 period, since fish during this period will still be in the lower Columbia River when spill is terminated during the last 10 days of August.

Smolt Survival: Estimated smolt survival was determined using NOAA Fisheries' SIMPAS spreadsheet model. SIMPAS estimated juvenile fish survival differences* are listed below, and are based on: a) model studies for the first 21 days of August with BiOp spill on at all four FCRPS dams compared to BiOp spill on at Ice Harbor and John

Day and BiOp spill off at The Dalles and Bonneville dams; and b) a comparison of studies for the last 10 days of August with BiOp spill on and off at all four dams. Low impact estimates represent the low end of the survival input ranges and the high impact estimates include the high end of the ranges. The low impact estimate represents the smallest difference in survival between the no spill and spill conditions.

System survival differences for wild SR fall chinook originating at Lower Granite are:

August 1-21 low impact difference is: 0.00037 or 0.037%
 August 1-21 high impact survival difference is: 0.00059 or 0.059%
 August 22-31 low impact difference is: 0.0014 or 0.14%
 August 22-31 high impact difference is: 0.0028 or 0.28%

Estimated Juvenile Fish Losses: Estimated juvenile fish losses due to the operational change in spill was determined using the simple equation: smolt population x distribution x SIMPAS model survival difference. Table 2 illustrates the results of the estimated juvenile fish loss estimates.

Table 2.

	Estimated number of smolts lost under low/high impacts and different fish distributions.					
Listed wild SR fall chinook	Early Migration Year		Middle Migration Year		Late Migration Year	
	Low Impact	High Impact	Low Impact	High Impact	Low Impact	High Impact
July impact	0	0	0	0	0	0
August 1-21 impact	78	123	124	197	150	238
August 22-31 impact	65	133	352	724	343	706
Est'd. Total Fish Loss²	140	260	480	920	490	940

- * Some of the more important SIMPAS modeling assumptions were:
- Smolt population starts at the face of LWG dam.
 - Since 2004 forecasted runoff condition is between 2003 and 2001 water conditions, pool survivals used are the mean of 2001 and 2003 pool survivals.
 - August (25 kcfs in Snake, and 112 kcfs in Columbia) flows are based on average of 2001 and 2003 flows for these periods.
 - D-value of 0.20 was applied to all transported fish to obtain system survival.

² Total impact estimates of smolts lost are rounded to the nearest 10.

- Pool survivals were reduced from 1 and 4% for the non-surface collection dams (IHR and JDA) and reduced by 0.5 to 2% for those dams with surface collection for non-spill operations (TDA, BON) to account for additional migration delay and predation under a no spill condition.
- A BON corner collector efficiency of 46% was used for fish entering the forebay (1999 RT data) with a survival rate of 98% with spill; and a survival rate of either 98% or 95% without spill for the low and high impact, respectively.
- For the high impact runs, August FGE estimates were lowered by a 10% relative change to allow for the reduction in FGE seen later in the season. FGE values remained at the 2000 BiOp levels in the low impact runs.

Other Issues:

Any extra mortality that may result from differential delayed route-specific mortality (i.e., is 98% bypass survival the same as 98% spill mortality after the fish leave the river?) is not included in this analysis. Also, the observation that late-migrating juvenile fall chinook have shown relatively higher smolt-to-adult return rates than earlier migrating fish has not been factored into this analysis.

Analysis of Biological Benefit of Additional 100 Kaf Flow Augmentation from Brownlee Reservoir

This potential offset action was proposed in recent comments by the states of Oregon and Washington, and calls for BPA to work with Idaho Power Company to provide an *additional 100 Kaf draft* from Brownlee Reservoir during July. This additional flow augmentation, which would be over and above the discharge that Idaho Power normally releases in July, would provide an additional flow benefit for a large percentage of listed SR fall chinook juveniles typically migrating in the Snake River during the month of July.

Corps' Flow and Temperature Modeling

The Corps of Engineers used its hydrodynamic-water temperature model CE-QUAL-W2 of Lower Granite Reservoir to forecast the velocity and thermal fields in the Snake River from Lower Granite Dam to RM 144 (near Anatone gage) for several flow conditions with and without 100 Kaf of additional discharge released from Brownlee Reservoir during the July 7-28 period, based on input from BPA. In the temperature modeling, the 100 Kaf additional volume was uniformly distributed during a 22-day period in July and was added to base flow conditions in the Snake River at Anatone for three years of simulation. Three recent years were selected for simulation -- 1998, 2000, and 2001 -- represented above average, average, and low flow water conditions, respectively based on the total cumulative discharge during July and August as observed at the Anatone gage.

The observed daily average discharge and water temperature on the Snake River at Anatone were used to estimate the thermal loading to Lower Granite pool for the base

conditions in each of the study years. A second scenario for each year assumed these base flows were augmented by 2.3 kcfs during a 22-day period from July 7 – July 28 at the observed historic temperatures. The Corps applied historic water temperatures to the proposed Brownlee-augmented flow conditions assuming that the heat exchange associated with the higher flows in the Snake River will be similar to historic conditions.

The observed daily average discharge and water temperature on the Snake River at Spalding were used as boundary conditions for thermal loading from the Clearwater River into Lower Granite Pool. Dworshak Reservoir was drafted from elevation 1600 feet (full pool) to elevation 1520 feet by the end of August for each of the three study years. The Corps’ May 19, 2004, memo (attachment 1) includes three tables showing daily average flows and water temperatures from Lower Granite Dam under both the base condition and for the simulated 100 Kaf Brownlee flow augmentation condition. These tables also summarize the potential thermal impact of the Brownlee flow releases below Lower Granite Dam for above average (1998), moderate (2000), and low flow (2001) conditions. From the Corps’ modeling results, introducing the 100 Kaf volume during July 7-28 period could cause a small (0.1 to 0.2 C) increase in tailrace water temperatures at Lower Granite Dam.

Analytical Approach

Staff used the changes in average daily flows and water temperatures from the Corps’ CE-QUAL-W2 model (Table 3) to estimate the biological effect of the additional Brownlee discharge. To estimate juvenile fish survival, B. Connor's (USFWS) regression model was used, where $survival = 140.82753 + 0.02648 * flow (m3/sec) - 7.14437 * temp (degrees C)$. Temperature and flow input parameters and estimated juvenile fish survival rates, with 95% prediction limits, are presented in Table 3.

Table 3.

July BRN Operation	Temperature blw LWG Dam (C)	LWG Outflow (m3/sec)	Est'd. juv. fish survival, in percent	95% prediction limits, in %
Base case – low flow	19.5	980.5	27.5	19.7 – 35.3
w/100 Kaf flow aug.	19.6	1045.4	28.5	20.7 – 36.3
Base case – mod flow	19.0	1134.9	35.1	28.9 – 41.4
w/100 Kaf flow aug.	19.1	1199.8	36.1	29.9 – 42.4
Base case – abv avg Q	20.06	1671.9	41.8	32.1 – 51.5
w/100 Kaf flow aug.	20.14	1736.3	42.9	32.7 – 53.2

Results: In each of the water conditions, juvenile fish survival is estimated to change by about 1% from the base case operation compared to the additional 100 Kaf flow augmentation operation from Brownlee (see Table 3). B. Connor’s regression model predicts this slight increase in juvenile fish survival through the Lower Granite project because the 2.3 kcfs additional flow release from Brownlee spread over a 3-week period

during July would slightly increase water velocity, thereby decreasing fish travel time, in the Lower Granite reservoir. However, the expected increase in survival as a result of the additional Brownlee discharge during July is also slightly counterbalanced by an expected 0.1 to 0.2 degrees C increase in water temperature, according to the Corps' water quality model.

SR fall chinook migration timing in Lower Granite Pool: The major components of wild Snake River fall chinook production above Lower Granite Dam over the 1998-2002 period include fish from the mainstem Snake River (61%), Clearwater River (29%), Grande Ronde River (6%), Imnaha River (3%), and the Salmon River (1%). We separated the Clearwater Basin production (29%) from the remaining Snake River and other tributaries' production (71%), as Clearwater River fish tend to migrate later in the summer, on average, than the Snake River fish. As USFWS has implemented a marking program over the past 11 years in the mainstem Snake River above Lower Granite Reservoir, we reviewed the PIT-tag detection data at Lower Granite dam for wild SR fall chinook and selected passage years 2003, 1996 and 1995 to represent early, middle and late migration timing, respectively, for juvenile migrants from the mainstem Snake River and its tributaries above Lower Granite Reservoir (other than Clearwater River).

There are only two years of PIT-tag data for Clearwater River fish at Lower Granite Dam, 1995 and 1998. The 1998 migration timing data was used to represent an early migration year.³ The 1995 migration timing data was selected to represent a middle, or typical, migration pattern.⁴ As there is no additional passage timing data for Clearwater River fish, the 1995 migration timing data, shifted later into the summer by two weeks, was used to represent a late migration pattern at Lower Granite Dam.

Using wild SR fall chinook migration PIT-tag data for timing of the Snake River populations, the estimated juvenile survival improvement applies to the various proportions of the migration affected at Lower Granite Dam during the July 8 through July 29 Brownlee flow augmentation period for early, middle and late migration patterns (Table 4). Similar early, middle and late passage timing information was developed and used for the Clearwater River population (Table 4).

Table 4.

Flow Operation Period (July 8-29)	Early Migration Year	Middle Migration Year	Late Migration Year
Snake R. populations	17.5%	43.2%	41.2%
Clearwater R. popul.	39.1%	13.3%	10.0%

Method: NOAA Fisheries staff estimated the potential survival benefit in juveniles of the additional July draft from Brownlee Reservoir using the following calculation:

³ 1998 was picked as early migration pattern due to warmer than normal winter and spring air and water temperatures in North Fork Clearwater River below Dworshak Dam, likely resulting in an early emergence and outmigration (DART data).

⁴ 1995 was selected as middle migration pattern due to more mid-point winter-spring air temperatures at Dworshak Dam, and thus a more average emergence and outmigration timing (DART data).

(% of migration affected during July 8-29) x (number of fish at head of pool)⁵ x (estimated juvenile fish survival improvement).⁶ The estimated juvenile fish benefit from the additional Brownlee flow augmentation was calculated for early, middle and late migration patterns and low flow, moderate flow and above average flow conditions based on the Corps' water quality model output. Note that this additional water would only benefit those SR fall chinook juveniles migrating during the July 8-29 period.

Results: The results of the benefit analysis of the Brownlee flow offset are shown in Table 5 below, and can be compared to the analysis of impacts of curtailing summer spill from Table 2. All juvenile fish numbers in Table 5 are based on system survival estimates of passage through all FCRPS projects to below Bonneville Dam.⁷

The analyses of both juvenile fish impacts and flow offset include considerable uncertainty, as it is difficult to predict a specific level of effect in either case. However, the estimates represent our best effort to inform the decision about the summer spill proposal with clear and open application of the best available scientific information.

Table 5.

	Comparison of estimated number of smolts impacted from summer spill reduction to estimated benefit of smolts gained from additional 100 Kaf Brownlee flow augmentation, for each estimate of impact and fish distribution.					
Listed wild SR fall chinook	Early Migration Year		Middle Migration Year		Late Migration Year	
	Low Impact	High Impact	Low Impact	High Impact	Low Impact	High Impact
Est'd. Total Fish Loss due to curtailment of BiOp spill	-140	-260	-480	-920	-490	-940
Est'd. Total Fish Benefit from BRN flow augment.	730	710	1070	1030	990	950
Est'd. Fish Benefit/Loss	+590	+450	+590	+110	+500	+10

⁵ Total estimated juvenile SR fall chinook run size is just over 1 million smolts at the face of LWG Dam.

⁶ The USFWS regression model was used to estimate juvenile fish survival through the Lower Granite pool to the dam.

⁷ Juvenile fish survival estimates through the FCRPS to below Bonneville Dam are based on a SIMPAS system survival estimate using 2001/2003 average August flows and pool survivals under a no spill condition.

References

Connor, William P., Howard L. Burge, John R. Yearsley and Theodore C. Bjornn. 2003. The influence of Flow and Temperature on Survival of Wild Subyearling Fall Chinook. *North American Journal of Fisheries Management* 23:362-375.

"Fall Chinook Salmon Spawning Ground Surveys in the Snake River Basin Upriver of Lower Granite Dam, 2002," by USFWS, Nez Perce Tribe and Idaho Power Company. September 2003. Report prepared for USDOE-BPA; project #199801003.