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MEMORANDUM

TO: Ed Bowles, ODFW

FROM: Michele DeHart

DATE: March 2, 2010

RE: NOAA proposed juvenile fish passage operation for 2010 in the Snake River

In response to your request the FPC staff analyzed the impact of the NOAA proposal presented to the ISAB on February 25, 2010 (NOAA 2010). NOAA proposes to eliminate spill for fish passage at Lower Granite (LGR), Little Goose (LGS), and Lower Monumental (LMN) dams from approximately May 1 through early June. These dates are approximate because the NOAA proposal leaves the initiation of the maximum transport/no spill operation to the Technical Management Team (TMT), while the end date is based on sub-yearling Chinook collections. Under the NOAA proposal, spill could be shut off as early as April 20th but no later than May 1 at LGR, May 5 at LGS, and May 8 at LMN. The date for start of spill for summer migrants is dependent on sub-yearling Chinook collections but will likely be early to mid-June.

On February 9, 2009, the FPC staff provided comments on the NOAA analysis entitled, *Analysis of juvenile Chinook salmon and steelhead transport from Lower Granite and Little Goose dams, 1998-2008* (NOAA 2009). It is worth noting that the discussion section of this NOAA analysis (NOAA 2009) states, "…the data presented here do not provide a complete basis for determining when to transport and when not." However, the 2009 NOAA analysis forms a part of the basis of the 2010 NOAA proposal to the ISAB. Specifically the use of the calculated T:M ratio. Our review of the analysis concluded that the T:M ratios were problematic and should be considered cautiously, and were not adequately robust to provide a basis for spill or passage management decisions. In their analysis NOAA implied that they would propose eliminating spill for two weeks in May to maximize the transportation of steelhead. In our review we concluded that the two week period of no spill and maximum transportation of steelhead would adversely impact a significant proportion of the total migration of juvenile salmon and steelhead remaining in-river.

Eliminating spill degrades conditions for all stocks remaining in-river and increases risk for salmon and steelhead remaining in-river in addition to creating adverse conditions for stocks that are adversely impacted by transportation. Historical timing data indicate that the two week period of no spill would impact 34-46% of yearling Chinook, 21-39%of sockeye and 23-39% of coho and 13%-18% of lamprey juvenile migration. This is an important consideration, in particular, for species that may not benefit from or for which transportation is detrimental, such as sockeye. The available data on sockeye is sparse, but all of the data indicates that transportation is detrimental to sockeye.

The NOAA submission to the ISAB presents an extreme maximum transportation proposal based upon steelhead transportation benefits, particularly from the 2007 outmigration year. Historically, Snake River steelhead transportation was maximized, with no spill for fish passage, for 20 years from 1975 to 1994. Snake River steelhead were listed as threatened under the Endangered Species Act on August 18, 1997.
The NOAA proposal essentially presents a mixed stock fish management problem, in which management actions that benefit one stock are detrimental to other stocks. The summary points of our review are listed, followed by detailed discussion.

- When compared to the present spread-the-risk transportation management approach being implemented, the NOAA proposal to eliminate spill for fish passage is extreme and increases risk. The present spread-the-risk operation represents a compromise which targets a 50%-50% transportation and in-river split.
- The spread-the-risk transportation management approach is a compromise that balances the detrimental effects of transportation on some stocks against benefits to others, while maintaining reasonable in-river, spill for fish passage, conditions for salmon, steelhead and lamprey remaining in-river.
- As with the previous NOAA proposal for a two week no-spill period, the present proposal has significant adverse impacts. The present proposal increases the proportions of other stocks affected by the maximum transport recommendation. On average (1998-2009), approximately 73.0-87.6% of steelhead juveniles passed LGR, LGS, or LMN during the period of the proposed maximum transport/no spill operation. Approximately 66.9-75.8% of Snake River yearling Chinook, 82.8-88.9% of sockeye, 86.8-88.7% of coho, 22.9-24.1% of subyearling Chinook, and 55.8-88.8% of lamprey juveniles also passed LGR, LGS, or LMN the proposed no-spill period.
- Given that such a high proportion of yearling Chinook, sockeye, coho, and lamprey juveniles pass these collector projects during this time, it is highly likely that eliminating spring spill from May 1st until the initiation of summer spill would significantly increase the proportion of these populations that would be transported.
- The BIOP measure that is the basis for the NOAA proposal was developed prior to data and analysis on the effects of spill for fish passage in a low flow year. Data collected in 2007, a low flow year with spill, indicated that there are substantial benefits to providing spill in a low flow year, in terms of juvenile survival, juvenile travel time and adult returns. Adult returns, in terms of the mixed stock nature of passage, indicate that the spread-the-risk transportation operation implemented in the low flow year of 2007 was successful for in-river migrants and transported migrants.

- From the data collected during the 2006 and 2007 juvenile migration, NOAA concluded that in-river survival increases with increasing spill through the indirect effect of reducing individual vulnerability to predation. More fish are left in-river to migrate as a result of spill, but bird predators can only remove a set amount leading to the lower overall proportion mortality and, consequently, higher in-river survival (Muir et al 2008). It is likely that, by increasing the proportion of steelhead that are transported from Snake River transportation projects, the NOAA proposal for 2010 will have an adverse impact on those steelhead that migrate in-river.
- Presently, available forecasts and historic data indicate that 2010 passage conditions are likely to be similar to 2007 in terms of flow. Juvenile survival, travel time and overall adult returns from 2007 indicate that the 2007 passage operation was successful.
- NOAA has proposed the maximum transportation operation as a response to concerns regarding poor passage conditions due to a predicted low flow year in 2010. However, NOAA's proposal will actually cause in-river migration conditions to be worse by eliminating spill. NOAA has not proposed any measures to mitigate the impact of the predicted low flow conditions.
- NOAA has discounted straying of transported steelhead. However, as the proportion of steelhead transported increases, the number of returning transported steelhead that will stray to Mid-Columbia and other tributaries increases. FPC estimates that with a maximum transport strategy, the number of straying transported adult steelhead entering Mid-Columbia tributaries could nearly equal the entire Mid-Columbia steelhead population.

Adverse Impacts of NOAA 2010 Proposal on other Snake River Salmonids:

For 2010, NOAA is proposing to eliminate spill and switch to a no spill/maximum transportation operation at Snake River transportation projects, beginning anywhere from April 21st to May 1st. Once this operation begins, it is assumed that the Snake River transportation projects will operate in this way until the initiation of summer spill. According to the 2008 Biological Opinion (2008 BiOp), summer spill volumes will begin "…when subyearling Chinook exceed 50% of the collection for a 3-day period for each Snake River project after June 1".

The primary rational for eliminating voluntary spill and implementing maximum transport is to increase the proportion of the steelhead run that is transported. This is based in large part on studies that indicate higher SARs for transported steelhead versus those that migrated in-river or were bypassed. Although transported steelhead have higher SARs than those migrating in-river or bypassed, this is not the case for wild Snake River spring/summer Chinook. Furthermore, what data there are suggest that there is no benefit to transportation for Snake River subyearling Chinook. It is unknown what kind of impact transportation has on Snake River coho but transportation may be detrimental to Snake River sockeye (Williams et. al., 2005). In addition to transportation potentially being detrimental to sockeye, the 2008 BiOp (Section 8.4.3.1) states that "despite changes in configuration and operations in the hydro system, rates of descaling and mortality are higher for sockeye than for other species, although the reason for this discrepancy is unknown". This implies that bypass systems at the projects may have more of an impact on sockeye juveniles compared to other species. Therefore, eliminating or reducing spill at Snake

River projects would effectively increase the proportion of juveniles encountering the juvenile bypass system and/or the turbines, and thus increase the potential for descaling and/or mortality.

Switching to maximum transportation with no spill in 2010 will inevitably increase the proportion of yearling Chinook, subyearling Chinook, sockeye, and coho that are transported, which could lead to a negative impact on these species, given the lack of data showing a benefit from transportation. Furthermore, switching to a no spill operation during this time could also have an impact on migrating juvenile lamprey, as a no spill operation would mean that all juvenile lamprey will be bypassed or pass through turbines instead of passing through spill.

To investigate the potential impact of operating at maximum transportation with no spill in 2010, FPC staff estimated the proportion of the population of yearling Chinook, steelhead, sockeye, coho, and subyearling Chinook passing Lower Granite (LGR), Little Goose (LGS), and Lower Monumental (LMN) dams during this time over the past twelve years (1998-2009). As mentioned above, the NOAA proposal is for this operation to begin between April 21st and May 1st. For this analysis, we assumed a common start date of May 1st at all three projects for this operation. The end date for each year was based on the 50% subyearling Chinook criteria outline above. With a start date of May 1st, these estimates of proportion passage are conservative, as the start date could be as early as April 21st. Estimates of proportion passage are based on the daily passage index for each species at LGR, LGS, and LMN.

FPC staff also estimated a passage index for juvenile lamprey at LGR, LGS, and LMN over the same twelve years. To do this, we expanded the daily sample counts of juvenile lamprey to a collection count, using the same expansion used for yearling Chinook or subyearling Chinook, depending on the time of year. These daily collection counts were then expanded to a daily passage index, which accounts for daily fluctuations in operations. Equation 1 provides the general equation used for the daily passage index for lamprey juveniles.

PI = total collection count * ((powerhouse flow + spill flow)/ powerhouse flow)) (1)

Results from this analysis can be found in Table 1 below. Based on the 50% subyearling Chinook criteria for initiating summer spill, the proposed operation would run through June 10th at LGR, June 13th at LGS, and June 14th at LMN, on average. On average, 73.0-87.6% of steelhead juveniles passed LGR, LGS, or LMN during the proposed period of the maximum transport/no spill operation. However, approximately 66.9-75.8% of Snake River yearling Chinook, 82.8-88.9% of sockeye, 86.8-88.7% of coho, and 22.9-24.1% of subyearling Chinook juveniles also passed LGR, LGS, or LMN during this time (Table 1). Furthermore, approximately 55.8-88.8% of lamprey juveniles passed LGR, LGS, or LMN during this time. Figures 1 through 3 provide an illustration of the average passage timing of each of the juvenile salmonids and lamprey, in relation to the proposed maximum transportation/no spill operation.

Given that such a high proportion of yearling Chinook, sockeye, coho, subyearling Chinook, and lamprey juveniles passed during this time at these collector projects, it is highly likely that eliminating spill from May 1st until the initiation of summer spill would significantly increase the proportion of these populations that would be transported. This is a particularly risky strategy, given that there is no evidence of transportation providing a benefit to these species and that this maximum transport/no spill operation would increase the number of lamprey juveniles that are bypassed or pass through the turbines.

Table 1. Annual percent of yearling Chinook, steelhead, sockeye, coho, subyearling Chinook, and lamprey juveniles passing Lower Granite, Little Goose, and Lower Monumental dams during the proposed period of no spill/maximized transportation operation (May 1-Initiation of Summer Spill).

Project	Year	Last Day of Max. Transport	Yearling Chinook	Steelhead	Sockeye	Coho	Subyearling Chinook	Lamprey Juvenile
LGR	1998	30-Jun	51.3	74.7	99.5	95.6	17.4	60.1
	1999	11-Jun	66.3	74.4	75.4	93.7	21.4	27.0
	2000	12-Jun	63.5	71.8	72.8	94.3	8.2	55.3
	2001	12-Jun	68.7	78.1	76.5	63.2	12.5	78.1
	2002	25-Jun	72.3	69.3	86.6	98.1	17.4	75.9
	2003	6-Jun	63.7	72.0	89.4	85.1	18.4	94.1
	2004	8-Jun	64.5	80.5	73.7	93.1	12.9	70.4
	2005	3-Jun	65.3	77.5	86.9	86.9	51.9	31.8
	2006	3-Jun	70.8	64.4	71.5	85.9	36.5	16.7
	2007	4-Jun	66.0	84.0	96.3	91.4	17.3	85.6
	2008	4-Jun	83.0	80.7	90.3	97.4	27.5	68.4
	2009	3-Jun	65.7	48.8	74.1	79.3	35.2	5.7
	Average	**10-Jun**	**66.8**	**73.0**	**82.8**	**88.7**	**23.1**	**55.8**
LGS	1998	30-Jun	69.5	90.0	98.0	95.4	8.9	77.3
	1999	23-Jun	74.0	84.5	82.4	96.7	28.4	84.9
	2000	17-Jun	63.7	47.1	66.0	82.7	16.7	61.7
	2001	26-Jun	86.7	86.6	85.9	35.7	7.9	88.1
	2002	18-Jun	86.2	79.4	85.0	96.0	15.5	25.7
	2003	16-Jun	80.3	88.4	96.9	96.3	38.5	98.8
	2004	11-Jun	63.3	73.3	90.6	84.5	27.2	94.0
	2005	3-Jun	94.5	95.8	83.4	97.1	33.7	66.1
	2006	3-Jun	74.2	67.3	77.1	88.8	30.1	19.6
	2007	8-Jun	98.6	95.4	97.4	94.1	17.2	47.5
	2008	6-Jun	94.7	89.8	91.9	98.9	17.4	87.9
	2009	3-Jun	70.6	45.3	81.6	80.7	33.0	24.9
	Average	**13-Jun**	**79.7**	**78.6**	**86.3**	**87.2**	**22.9**	**64.7**
LMN	1998	30-Jun	67.4	90.9	99.4	98.9	29.1	59.7
	1999	25-Jun	79.5	91.7	86.2	98.9	20.2	78.2
	2000	12-Jun	60.6	66.3	84.3	85.3	27.1	91.4
	2001	30-Jun	67.2	84.8	83.2	26.8	17.3	98.2
	2002	28-Jun	97.3	98.3	97.3	97.3	16.4	77.4
	2003	6-Jun	66.2	90.1	68.3	89.5	18.4	99.5
	2004	10-Jun	27.3	69.9	87.1	89.2	31.3	92.6
	2005	5-Jun	62.8	87.1	80.9	97.7	20.7	91.2
	2006	3-Jun	91.6	85.7	92.1	91.3	32.4	98.6
	2007	9-Jun	97.4	98.7	98.3	97.3	27.2	94.3
	2008	8-Jun	95.6	96.5	98.5	99.8	28.1	99.2
	2009	3-Jun	96.6	90.9	91.6	69.4	21.0	86.1
	Average	**14-Jun**	**75.8**	**87.6**	**88.9**	**86.8**	**24.1**	**88.8**

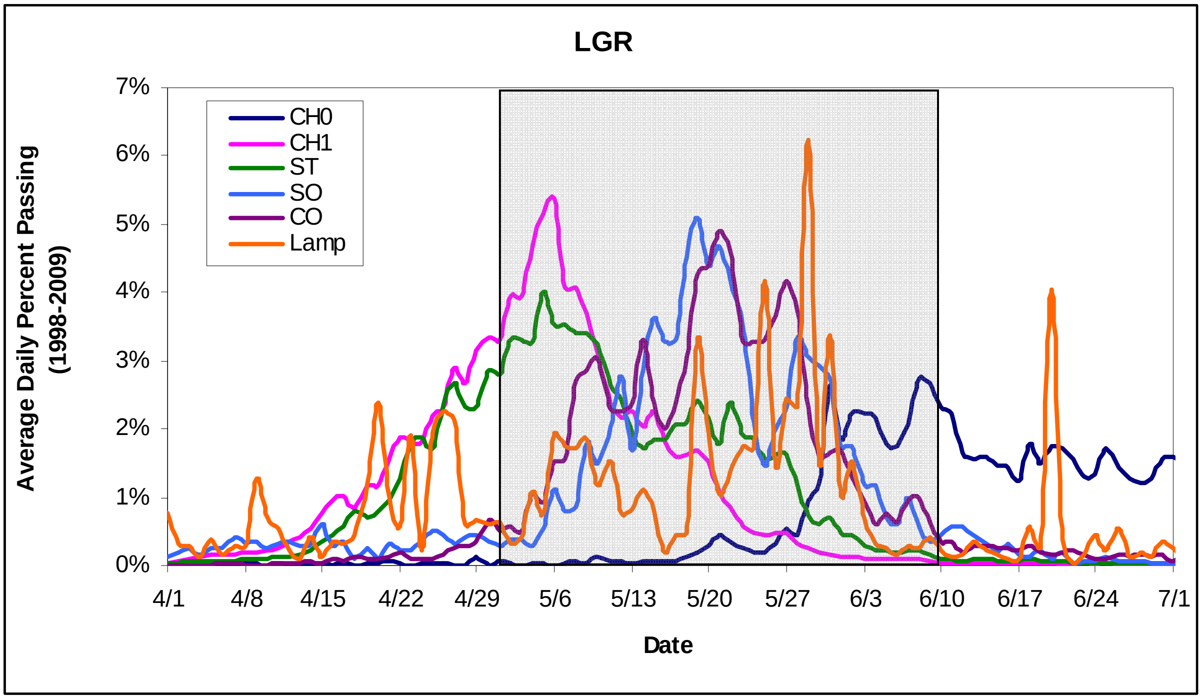

Figure 1. Average daily percent passing for subyearling Chinook, yearling Chinook, steelhead, sockeye, coho, and lamprey (1998-2009) in relation to proposed maximum transportation/no spill operation for 2010. Shaded area depicts the proposed NOAA operation, with an assumed start date of May 1st and the average end date of June 10th at Lower Granite Dam

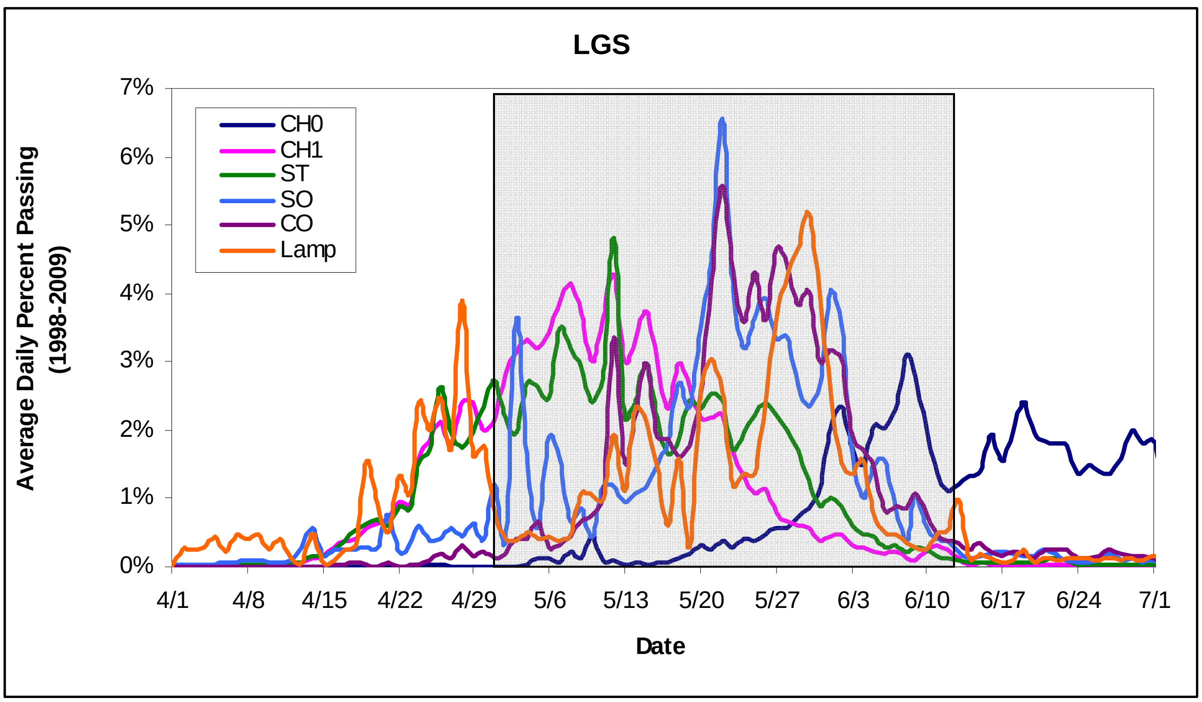

Figure 2. Average daily percent passing for subyearling Chinook, yearling Chinook, steelhead, sockeye, coho, and lamprey (1998-2009) in relation to proposed maximum transportation/no spill operation for 2010. Shaded area depicts the proposed NOAA operation, with an assumed start date of May 1st and the average end date of June 13th at Little Goose Dam

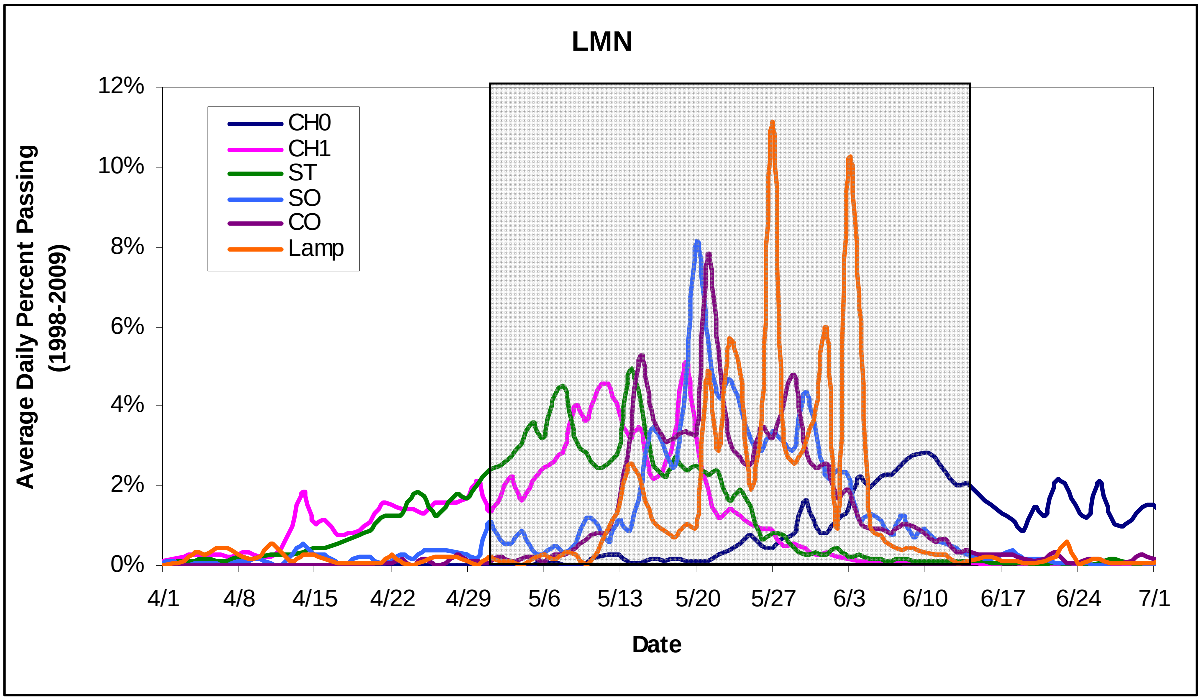

Figure 3. Average daily percent passing for subyearling Chinook, yearling Chinook, steelhead, sockeye, coho, and lamprey (1998-2009) in relation to proposed maximum transportation/no spill operation for 2010. Shaded area depicts the proposed NOAA operation, with an assumed start date of May 1st and the average end date of June 14th at Lower Monumental Dam

Spread-the-risk management approach to transportation

Table 2 illustrates the proportion of each stock transported from the Snake River in past years. The spread-the risk operation with the court ordered spill operation occurred from 2006 through 2009. Transportation of smolts was maximized in 2005 and all prior years. However, involuntary spill sometimes occurred in high flow years during this period. As illustrated in Table 2, even under the spread-the-risk management strategy, greater than 50% of sockeye juveniles are still being transported.

Table 2. Comparison of the 2009 estimate of the proportion of Snake River Basin smolt population in Lower Granite Dam forebay that are "destined for transportation" and the corresponding estimates from 2000 to 2008. For yearling Chinook and steelhead, the results exclude transport at McNary Dam.

Species- age group	Transport Proportion									
	2009	**2008**	**2007***	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**
Yearling Chinook	0.36 (H) 0.40 (W)	0.493 (H) 0.488(W)	0.242 (H) 0.168 (W)	0.611 (H) 0.579 (W)	0.92	0.870	0.629	0.683	0.980	0.71
Steelhead	0.46 (H) 0.48 (W)	0.41 (H) 0.447(W)	0.47 (H) 0.437 (W)	0.76 (H) 0.793 (W)	0.94	0.964	0.670	0.677	0.986	0.81
Subyearling Chinook	0.51 (H) 0.45(W)	0.581 (H) 0.463(W)	0.357 (H) 0.358 (W)	0.521 (H) 0.562 (W)	0.809	0.972	0.895	0.929	0.962	0.93
Sockeye	0.654	0.620	0.532	0.592	0.859	0.952	0.758	0.663	0.950	0.518

*NOTE: 2007 operations included 14 nights of spill to the gas cap at Little Goose Dam leading to the lower proportion of Chinook transported compared to other years when spread-the-risk was implemented.

Spread-the-risk, court ordered spill operations for the 2007 outmigration, was successful in terms of overall adult returns, juvenile survival and juvenile travel time. Repeating the operation in 2010 will provide a valuable opportunity to collect additional data to support future management decisions.

The result of the spread-the-risk transportation, court ordered spill for fish passage, low flows, and marine conditions in 2007 is largely reflected in adult returns in 2009. Improved adult returns, particularly for steelhead and sockeye, resulted from the 2007 out-migration. The FPC reviewed steelhead returns from the 2007 outmigration in a memorandum dated August 27, 2009 (FPC memo 8/27/2009). At that time the total steelhead adult count at Bonneville Dam exceeded the previous record count. The near-record steelhead return in 2009 was primarily comprised of juvenile out migrants from 2007 and 2008. In addition, the FPC updated sockeye data in a memorandum dated January 16, 2010 (FPC memo 1/16/2010). Sockeye returns to the Snake River reached a record historical high in 2009. Based upon PIT tagged sockeye, 87% of sockeye adults returning in 2009 out-migrated in 2007. Previous low flow years, without spill and with maximum transportation of sockeye, resulted in dismal adult returns.

In their proposal to the ISAB, NOAA did not discuss specific issues that would have impacted the SARs of in-river migrants in 2007. Specifically, in-river migrants experienced adverse passage conditions in 2007 due to TSW configuration tests at McNary Dam. Steelhead in-river migrants experienced decreased spillway survival due to these tests. When considering a passage operation based largely on one year of data, such as the NOAA proposal, all factors should be considered such as project specific actions that could effect in-river survival, which could affect the comparison of in-river versus transportation benefits. For example, a different occurrence at Bonneville Dam, in which excessive debris caused high bypass mortality and removal of turbine passage screens for most of the spring migration in 2008, will have to be considered when passage operations are assessed for that year. An additional example is the specific spill for fish passage operation at Little Goose Dam in 2007 which was developed by agreement among the parties. In 2007, 14 nights of spill to the gas cap occurred during the peak of the spring/summer Chinook downstream migration at Little Goose Dam. This resulted in the transportation of less than 25% of the hatchery and wild Chinook for 2007 (Table 2). The effect of this operation on the survival and adult return of spring Chinook will be evaluated when the full component of adults returning from this juvenile migration condition is complete.

Provision of spill in low flow years has occurred twice, once in the late spring of 2001 at McNary and John Day dams from May 25 to June 15 at The Dalles and Bonneville dams from May 16 to June 15, and again during both the spring and summer migrations in 2007. For the summer migration in 2001, spill was curtailed at McNary and John Day dams and delayed to occur only from July 21 to August 31 at The Dalles and Bonneville dams. Both instances resulted in increased juvenile survival during the periods when spill was provided. Migration year 2007 was the first and only opportunity to collect data throughout the entire migration on all species. Additional data under this operation would be valuable for future passage management decisions. Prior to the implementation of the spread-the-risk transportation management approach, a maximum transportation no-spill operation had been implemented for 20 years from 1975 to 1994.

Over the past ten years, the sites of bird colonies in McNary reservoir have been sampled for PIT tags after the nesting season. Data have shown that a considerable number of PIT tags were recovered and that percentage of tags recovered on the colonies are higher for steelhead than for Chinook. The number of tags recovered is variable from year to year. In most years, the estimate of juvenile steelhead mortality due to bird predation was about 4 to 5%, but could be as high as 21% observed in 2001 (Faulkner et al. 2007, Faulkner et al. 2008). NOAA analyses have concluded that much of the in-river mortality for steelhead is from bird predation that occurs in the McNary reservoir. Since the initiation of the Court Ordered spill program and spread-the-risk management strategy, the estimated in-river survival of juvenile steelhead has increased. NOAA Fisheries has hypothesized (2007, 2008) that the increase in survival for in-river migrants is partially the result of a smaller overall proportion of smolts taken by avian predators.

More fish are left in-river to migrate as a result of spill, but bird predators can only remove a set amount leading to the lower overall proportion mortality and, consequently, higher in-river survival (Muir et al 2008). From the data collected during the 2006 and 2007 juvenile migrations, NOAA concluded that in-river survival increases with increasing spill through the indirect effect of reducing individual vulnerability to predation. Therefore, it is likely that, by increasing the proportion of steelhead that are transported from Snake River transportation projects, the NOAA proposal will have an adverse impact on the survival of those steelhead that migrate in-river. NOAA cautions that the direct or indirect effects of increased spill may not improve smolt-to-adult survival for the population (Muir et al. 2008).

Present volume runoff forecasts indicate that passage conditions in 2010 could be similar to 2007

Two methodologies were used to predict flows at Lower Granite Dam during the spring of 2010. The first prediction used 1975-2009 actual runoff volumes at Lower Granite Dam between April and July and the actual recorded average flow in each year at Lower Granite during the spring migration period, April 3-June 20. Figure 4 shows the relationship between actual runoff volume (April-July) and average spring flows (April 3-June 20) at Lower Granite Dam over the 35 years between 1975 and 2009.

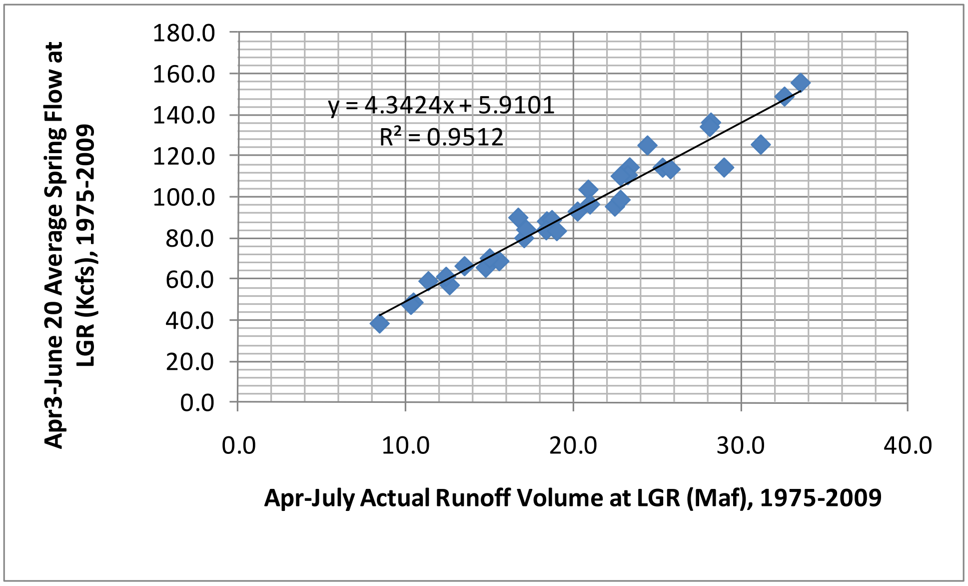

Figure 4. Relationship between actual runoff volume (April-July) and average spring flows (April 3-June 20) at Lower Granite Dam, 1975-2009.

The relationship between Lower Granite runoff volumes and average spring flows was utilized to estimate average spring flows at Lower Granite Dam in 2010 using the February Final, the February Mid-Month, and the March Early Water Supply Forecasts at Lower Granite Dam, issued by the River Forecast Center (RFC). Using the regression equation shown in Figure 4 and the three water supply forecasts issued by the RFC, three predictions of average flows over the spring of 2010 at Lower Granite were generated.

1. LGR February Final 2010 WSF (Apr-July)= 13.8 Maf:
   Predicted April 3-June 20 average flow at LGR = ***65.8 Kcfs***

2. LGR February Mid-Month 2010 WSF (Apr-July)= 13.3 Maf
   Predicted April 3-June 20 average flow at LGR = ***63.7 Kcfs***

3. LGR March Early 2010 WSF (Apr-July)= 12.7 Maf
   Predicted April 3-June 20 average flow at LGR = ***61.0 Kcfs***

The second methodology used to predict spring flows at Lower Granite Dam in 2010 utilized the February Final Water Supply Forecasts (WSF) (April-July) and actual average flows at Lower Granite (April 3-June 20) over the eleven years between 1999-2009. Figure 5 displays the relationship between the past eleven years February Final forecasts at Lower Granite (April-July) and the actual average spring flows (April 3-June 20) recorded in each of those years.

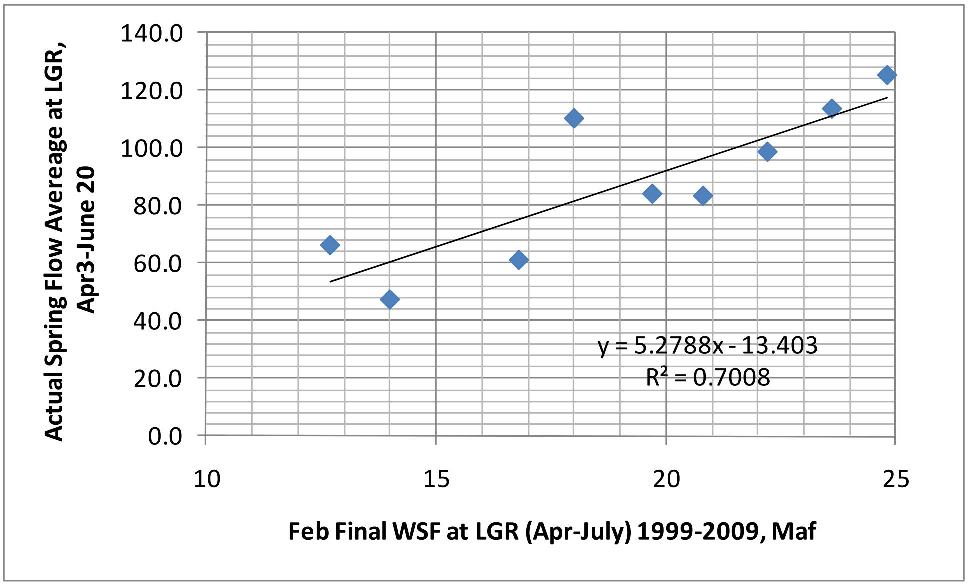

Figure 5. Relationship between the February Final WSF (April-July) and average spring flows (April 3-June 20) at Lower Granite Dam, 1999-2009.

Using the regression equation shown in Figure 5 along with the 2010 February Final WSF at Lower Granite (April-July) issued by the RFC, an additional prediction of average flows over the spring of 2010 at Lower Granite was generated.

1. LGR February Final 2010 WSF (Apr-July)= 13.8 Maf:
   Predicted April 3-June 20 average flow at LGR = ***59.4 Kcfs***

Based on current water supply conditions above Lower Granite Dam, in conjunction with the two prediction methodologies explained above, average spring flows at Lower Granite Dam between April 3 and June 20 are expected to fall well below the anticipated flow target at Lower Granite Dam of 85 Kcfs. It appears that average flows at Lower Granite Dam in 2010 may be comparable to flows seen in 2007 at Lower Granite. In 2007, the actual April-July runoff volume at Lower Granite was 12.4 Maf, slightly lower than water supply forecasts currently predicted by the RFC at Lower Granite in 2010. In 2007, spring flows averaged 61.2 Kcfs. However, the shape of the runoff did allow periods when daily flows exceeded flow targets. Figure 6, displays the shape of the 2007 spring runoff at Lower Granite Dam.

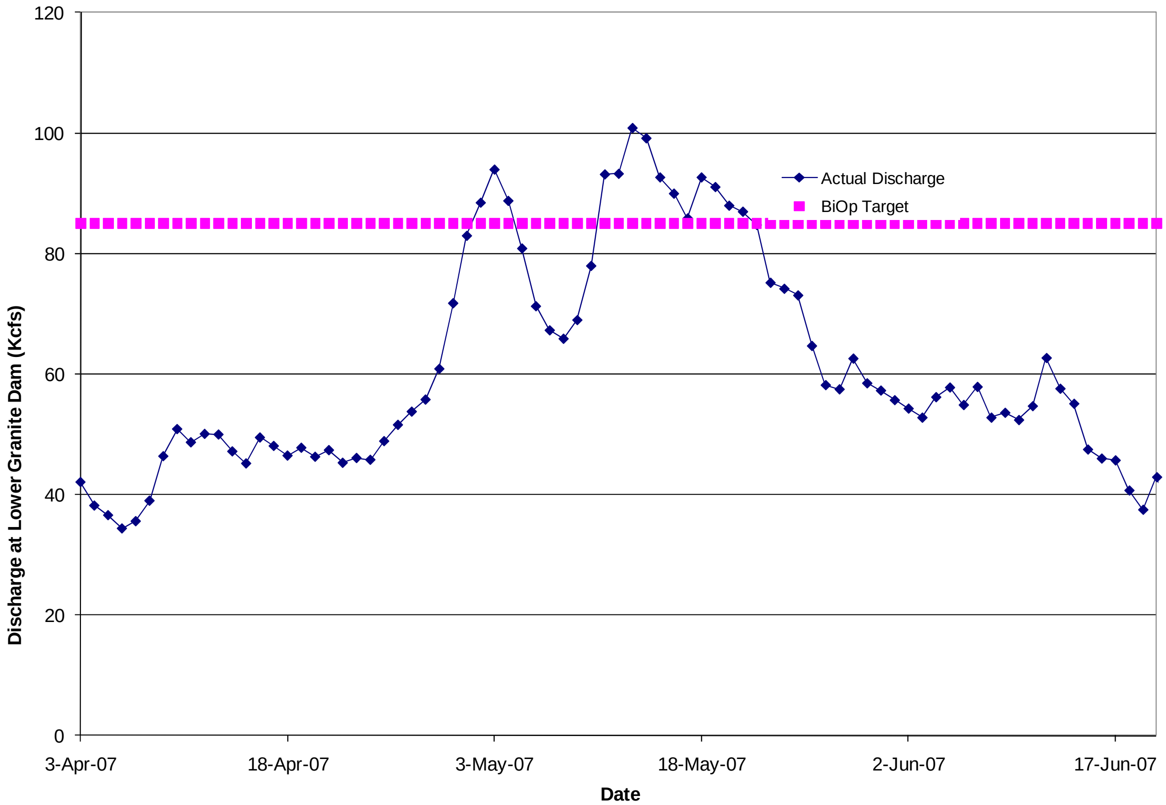

Figure 6. Actual discharge at Lower Granite Dam over the spring of 2007 and the 2007 Biological Opinion flow target.

Straying of transported steelhead is significant, when the size of the wild Deschutes, John Day and other Mid_Columbia ESU populations are considered

NOAA Fisheries (2008) estimated that transportation of steelhead increased straying rates above that of in-river migrants 3% to 5% in their Supplemental Comprehensive Analysis. The 2009 CSS Annual Report (Tuomikoski et al. 2009) estimated that steelhead straying for in-river migrants was in fact near zero (i.e. less than 0.2%) and that transport straying was at least 3% based on PIT-tag recoveries in recent years. The FPC estimated that roughly 60% of all steelhead strays were to the Mid-Columbia ESU tributaries. FPC used a combination of these straying rates to estimate what effect transporting different proportions of the Snake River steelhead populations would have on the number of strays into the Mid-Columbia River.

Steelhead adult returns to Lower Granite Dam have ranged from 117,000 to 312,000 in the years 2000 to 2009. Assuming 90% conversion rate to Lower Granite Dam from Bonneville Dam, the range of starting adult populations at Bonneville Dam would have been between 130,000 and 347,000 for those years. If transport resulted in an increase in straying of 3% to 5% above that observed for in-river migrants, then the impact in number of adult steelhead straying to Mid-Columbia River ESU could be calculated by multiplying the Bonneville population by the stray rate (5% or 0.05). However, since FPC estimated that 60% of strays were to Mid-Columbia ESU rivers, we then multiplied the total strays by 0.6 to adjust the overall rate to reflect the estimated proportion of transportation strays entering Mid-Columbia ESU tributaries. Table 3 shows the estimated **increase** in straying that could result from different transportation proportions. We showed the effects of different run sizes as well as different proportions of adults that were transported as juveniles.

There would likely be a survival loss (of up to 5% perhaps) prior to reaching some Mid-Columbia rivers, such as the Yakima but that would likely have a small impact on the overall estimated number of strays. Also, it is likely that much of the straying occurs in the Deschutes and John Day rivers (based on FPC analysis or recent PIT-tag returns) so that low mortality rates are likely prior to encountering these tributaries.

Table 3. Estimated increase in strays of Snake River Steelhead to Mid-Columbia ESU tributary populations based on proportion transported and total Snake River Steelhead adults to Bonneville Dam compared to in-river only adult returns as baseline.

Adult Steelhead to BON	Estimated increase in number of Snake River strays to Mid-Columbia ESU (as a function of proportion of Bonneville Dam adults that were transported as juveniles)				
	100%	80%	50%	10%	0%
350,000	10,500	8,400	5,250	1,050	0
237,500	7,125	5,700	3,563	713	0
125,000	3,750	3,000	1,875	375	0

Note: Mid-C steelhead geomean population was estimated at 11,214 for the NOAA Supplemental Comprehensive Analysis (NOAA 2008). Assumed 5% increased stray rate applied to Snake River steelhead population at Bonneville Dam and that 60% of strays entered Mid-Columbia ESU tributaries.

If we assumed that the proportion of adult steelhead returning to Bonneville Dam reflected the proportion transported (i.e. transport in-river ratio of 1), we could use the transport proportion impacts shown in Table 3 to predict the effects of transport operations on straying numbers to the Mid-Columbia ESU tributaries. As such, if steelhead transport proportion was near the 2001 level of 97%, then depending on total number of steelhead adult returns, the total **increase** in Snake River steelhead strays to the Mid-Columbia tributaries attributable to transport would be an estimated 3,750 to 10,500 fish. That represents an influx of Snake River strays equal to between 33% and 94% of the total estimated number of steelhead in the Mid-Columbia ESU. If the transport proportion was near 2007 levels of 47%, then the strays would equate to between 17% and 47% of the total Mid-Columbia ESU.

These estimated stray numbers likely under-estimate the true population of strays for three reasons. First, the transport proportion estimates used to illustrate the impacts from 2001 and 2007 are actually transport probabilities. These estimate the likelihood of a fish being transported from a collector dam, given that it alive in Lower Granite Dam forebay. It does not account for mortality through the collector dams. In fact the actual proportion alive in a barge below the last transport dam (Lower Monumental Dam) compared to in-river fish alive at the same location is higher, since in-river fish mortality is higher given that all of them have to pass through all three dams, while transport fish pass through 1 to 3 bypass/dams to arrive in barges below that dam. Second, the assumption of equal adult returns of transport and in-river steelhead (especially for hatchery fish) has not often occurred. Given a transport proportion of 50% it is likely that greater than 50% of adult returns would be of transport origin. Finally, tributary straying rates based on PIT-tag data requires detection arrays in tributaries and only in recent years have these detection arrays become available, and only in a few of the Mid-Columbia tributaries.

In any case, the impact of transport strays on Mid-Columbia steelhead ESU is likely significant given the high numbers of strays in those tributaries. In fact, the stronger the Snake River steelhead adult return and the higher the proportion transported, the higher the risk to Mid-Columbia stocks, particularly when transport is maximized.

Adaptive Management

The results from provision of spill in the low flow year of 2007 were unexpected. The benefits of spilling in a low flow year were far reaching and had not been apparent in previous data because spill had not been provided in low flow years. The results from the 2007 low flow spill operation are encouraging and surprising. Similar flows with the same operation in 2010 should allow the region to gain additional information regarding the appropriate hydro system operations for mixed stock passage management in the future. This is particularly true given the recent increased PIT-tagging efforts for Snake River Sockeye.

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