



# FISH PASSAGE CENTER

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## MEMORANDUM

TO: Liz Hamilton

FROM: Michele DeHart

DATE: July 14, 2008

RE: Sockeye adult returns in 2008

In response to your request, the FPC staff has reviewed the returns of adult sockeye in the Snake and Mid-Columbia rivers in 2008 and analyzed the in-river conditions and hatchery releases during recent out-migration years. These analyses are preliminary since the sockeye adult return is not complete.

- Sockeye adult returns to the Bonneville Dam in 2008 are nearly 4 times the 10-year average. Sockeye adult returns to Lower Granite are nearly 21 times the 10 year average.
- Approximately 80% of the Mid-Columbia PIT-tagged sockeye adults detected at Bonneville Dam out-migrated in 2006, while 20% out-migrated in 2007. Of the PIT-tagged Snake River sockeye adults detected at BON in 2008, 50% out-migrated in 2006 and 50% out-migrated in 2007.
- PIT-tagged juvenile sockeye from the Mid-Columbia had a reach survival from Rock Island to John Day dam of approximately 0.88, which was the highest survival among the years analyzed. Reach survival in 2007 was 0.56, the second highest among the years analyzed. Migration year 2006 also had the shortest water transit times. Weighted regression analyses revealed that, as water transit time decreases, reach survival increases.
- Beginning in migration year 2006, releases of hatchery sockeye in the Mid-Columbia have increased substantially. This is due primarily to the release of unclipped fry into Lake Skaha.

- PIT-tagged juvenile sockeye from the Snake River had a reach survival from Lower Granite to John Day dam of approximately 0.86, which was the highest survival among the years analyzed. Reach survival for migration year 2007 was 0.62. Weighted regression analyses revealed a strong relationship between water transit time and reach survival. As water transit time decreases (as flow increases) reach survival increases. There was also a strong relationship between average percent spill and reach survival for Snake River sockeye indicating that survival increases as spill increases. Finally, the estimated proportion of juvenile fish transported was low in both 2006 and 2007, compared to the other years.
- The high returns of sockeye adults is likely due to a combination of conditions which occurred during the 2006 and 2007 juvenile out-migrations, including:
  - Higher flow and spill during 2006
  - Higher proportion of river flow spilled in the lower flow year of 2007
  - Improved spill operations at McNary Dam in 2006 and 2007 changing the operation from the previous night time spill only, to 40% spill to the gas cap 24 hours per day.
  - Improved spill operations at John Day in 2006 due to a T1 line outage which forced the project to spill 40% of river flow, 24 hours per day
  - Lower proportion of juvenile sockeye transported at Snake River projects.
  - Increased hatchery production in the upper Columbia River by Fisheries and Ocean, Canada
- At this time, there is no evidence of straying among PIT-tagged Mid-Columbia sockeye adults to the Snake River, based on detections of adults at Ice Harbor and/or Lower Granite dams.

### **Sockeye Adult Returns in 2008**

The total adult sockeye count at Bonneville Dam (BON) for this year is 211,794, as of July 13, 2008 (Table 1). This total count is nearly 4 times the 10-year average at BON by this point in the migration. Based on counts at Priest Rapids Dam (PRD) and Ice Harbor Dam (IHR), the vast majority of the sockeye adults returning to BON are of Mid-Columbia origin. However, returns of adult sockeye to Lower Granite are the highest on record since counting at the dam began in 1975.

**Table 1.** Adult Sockeye counts (as of listed end date) at Bonneville, Priest Rapids, Ice Harbor, and Lower Granite Dam. Counts are based on historic count dates, beginning March 15<sup>th</sup>.

<b>Project</b>	<b>End Date</b>	<b>2008 Counts</b>	<b>10-yr Average</b>
BON	7/13	211,794	56,496
PRD	7/10	172,170	43,944
IHR	7/13	501	34
LGR	7/13	691	33

Based on PIT-tags, approximately 80% of the Mid-Columbia adult sockeye detected at BON out-migrated in 2006, while 20% out-migrated in 2007. However, of the Snake River sockeye detected at BON so far, 50% out-migrated in 2006 and 50% out-migrated in 2007.

### **Mid-Columbia Sockeye**

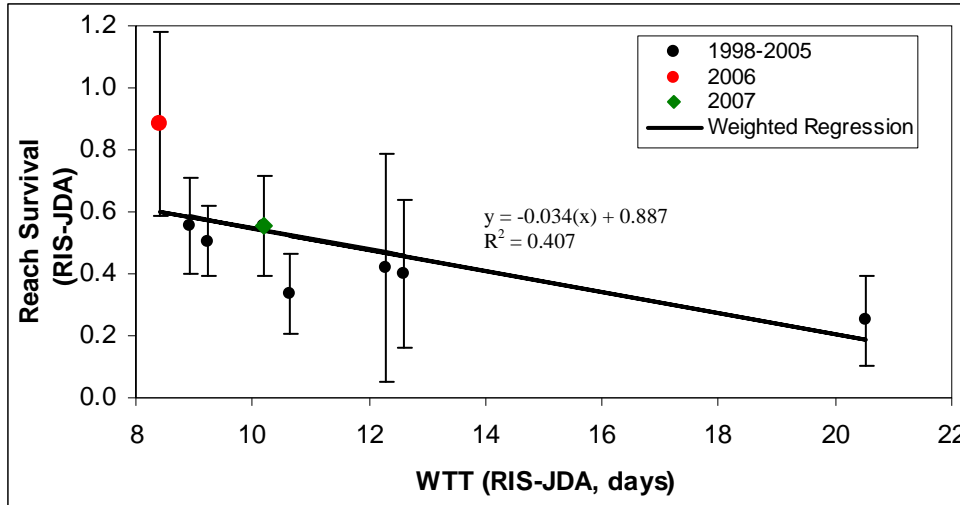
In order to determine how the Court Ordered spill program may have influenced the 2008 adult sockeye returns, the FPC staff analyzed in-river conditions in 2006 and 2007, compared to past years (1998-2005). Specifically, FPC staff estimated juvenile reach survivals for Mid-Columbia sockeye based on releases of PIT-tagged individuals at Rock Island Dam (RIS). Due to limited sample sizes, only estimates of survival from RIS to John Day Dam (JDA) were possible for all years. These same PIT-tagged individuals were used to estimate median fish travel times from the point of release to McNary (MCN) and JDA. With these travel times, we estimated the water transit time (WTT), fish travel time (FTT), average flow, and average percent spill that these out-migrants would have experienced during their out-migration from RIS to JDA. The estimation of reliable environmental variables requires that the window of time is as small as possible. In order to minimize this window, we only analyzed PIT-tags released at RIS between April 15<sup>th</sup> and May 26<sup>th</sup> of each year.

In addition, FPC staff reviewed hatchery release data for 2006 and 2007, compared to past years. For this analysis, we tallied hatchery releases of sockeye in the Mid-Columbia region (MCN to Chief Joseph Dam) based on their expected year of out-migration. Due to recent changes in hatchery releases in this zone, we included releases of fry.

Among the migration years analyzed, 2006 and 2007 resulted in the highest estimates of juvenile reach survival (RIS-JDA), at 0.88 and 0.56, respectively (Table 2). One potential explanation for the high survival in 2006 could be the high flows and, therefore, short water transit times. In fact, weighted regression analyses showed a strong relationship between water transit time and juvenile reach survival (RIS-JDA), where reach survival increases as water transit time decreases (Figure 1).

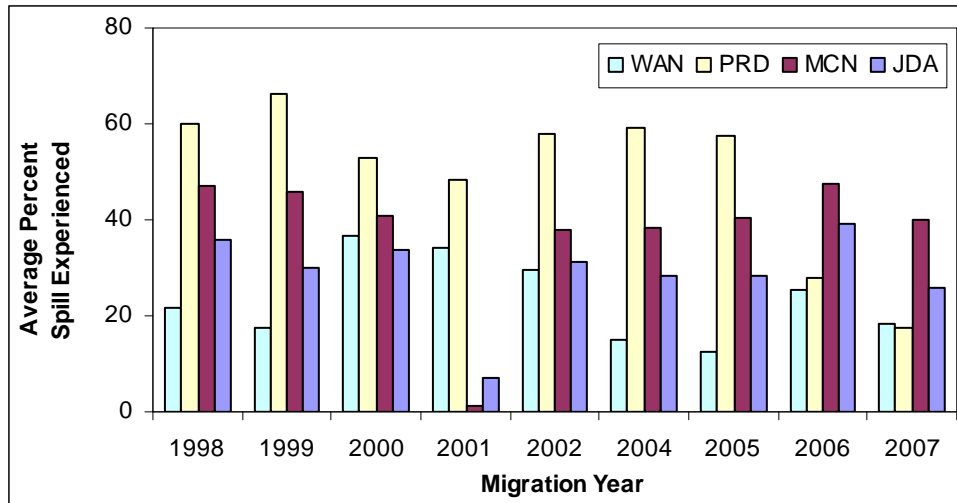
**Table 2.** Juvenile survival (RIS-JDA) and in-river conditions experienced by PIT-tagged sockeye juveniles released from RIS. Survival estimate to JDA was not possible in migration year 2000 due to small sample size. No juvenile sockeye were PIT-tagged at RIS in 2003.

Migration Year	Average Flow (Kcfs)	Fish Travel Time (days)	Water Transit Time (days)	Average Spill Percent	Juvenile Survival (RIS-JDA)	95% Confidence Interval	
						Lower Limit	Upper Limit
1998	222.1	16.2	8.9	32.8	0.55	0.40	0.71
1999	215.7	11.4	9.2	31.9	0.50	0.39	0.62
2000	208.6	11.6	9.9	32.8	N/A	N/A	N/A
2001	91.9	23.3	20.5	18.1	0.25	0.10	0.40
2002	191.2	10.9	10.6	31.3	0.33	0.20	0.46
2004	157.7	10.9	12.6	28.2	0.40	0.16	0.64
2005	160.3	11.0	12.3	27.7	0.42	0.05	0.78
2006	238.7	10.2	8.4	28.0	0.88	0.59	1.18
2007	204.1	10.1	10.2	20.3	0.56	0.40	0.72



**Figure 1.** Weighted regression of water transit time and juvenile reach survival (RIS-JDA) of PIT-tagged Mid-Columbia River sockeye juveniles released at RIS.

In the Rock Island to John Day reach, average spill proportion had little variation with the exception of 2007. Because the average spill variable did not change much over the years analyzed, this variable did not affect the reach survival estimate. However, there have been substantial changes in the spill operations on a per project basis (Figure 2). For example, out-migrants prior to 2005 would have experienced 48% to 66% spill at Priest Rapids Dam, whereas those out-migrating in 2006 and 2007 experienced only 27% and 17% spill, respectively. Furthermore, 2006 out-migrants experienced the largest percent spill at MCN among the years analyzed, particularly when compared to 2001-2005. One reason for this increase in spill percent at MCN in 2006 was a change in operations. In 2006, spill at MCN was 40% of instantaneous flow for 24 hours, whereas spill in previous years was night-time spill to the gas cap. Spill percent at JDA in 2006 was also the highest among the years analyzed. Like MCN, spring operations at JDA in 2006 were different than previous years. In previous years, spill at JDA was limited to 60% of instantaneous flow during night-time hours. However, due to a T1 line outage in 2006, the spill at JDA in 2006 was 24 hours, at approximately 40% of instantaneous flow.



**Figure 2.** Average percent spill experienced by PIT-tagged sockeye juveniles at Wanapum, Priest Rapids, McNary, and John Day dams.

**Table 3.** Hatchery releases (by migration year) of sockeye smolts and fry in the Mid-Columbia Zone.

Migration Year	Total Smolts Released	Total Fry Released	Total Juveniles Released	Percent Fry
1998	365,784	0	365,784	0
1999	210,591	0	210,591	0
2000	142,901	0	142,901	0
2001	241,216	0	241,216	0
2002	308,042	0	308,042	0
2003	208,986	0	208,986	0
2004	315,790	0	315,790	0
2005	240,459	352,500	592,959	59
2006	172,923	1,205,500	1,378,423	87
2007	140,542	1,384,000	1,524,542	91

Beginning in migration year 2006, there has been a substantial increase in the number of hatchery sockeye released in the Mid-Columbia over the past few years (Table 3). This is primarily due to releases of sockeye fry into Lake Skaha by Fisheries and Ocean, Canada. These fry are released into Lake Skaha in the spring but don't out-migrate as smolts until the following spring. These fry releases first began in the spring of 2004, with 352,500 individuals released for out-migration in spring 2005. Since these fry are so small at the time of release, they are not marked with external marks or tagged with PIT-tags. It is worth noting that there is no estimate of survival from fry to smolt for these individuals so there is no way to know to what degree they contributed to the adult returns in 2008. All other sockeye juveniles released in the Mid-Columbia are clipped (AD, LV, or RV).

Therefore, it is likely that the increased adult returns of Mid-Columbia sockeye is the combination of good in-river conditions in 2006 (e.g., increased percent spill at MCN and JDA) and increased juvenile reach survivals and hatchery output in migration years 2006 and 2007.

## **Snake River Sockeye**

In order to determine how the Court Ordered spill program may have influenced the 2008 adult sockeye returns to the Snake River, the FPC staff conducted a similar analysis as that for the Mid-Columbia sockeye. Specifically, FPC staff estimated juvenile reach survivals of PIT-tagged individuals from Lower Granite Dam (LGR) to McNary Dam (MCN). In order to increase sample sizes, individuals that passed LGR undetected but had first-time detections at Little Goose Dam (LGS) were used in this analysis. These same PIT-tagged individuals were used to estimate median fish travel times from the point of LGR detection to MCN. With these travel times, we estimated the water transit time (WTT), fish travel time (FTT), average flow, and average percent spill that these out-migrants would have experienced during their out-migration from LGR to MCN. The estimation of reliable environmental variables requires that the window of time is as small as possible. In order to minimize this window, we only analyzed PIT-tagged sockeye that were detected at LGR between May 8<sup>th</sup> and June 4<sup>th</sup> of each year. This window was extended down to LGS for those individuals that were first detected at LGS, based on the median travel time from LGR to LGS for each particular year.

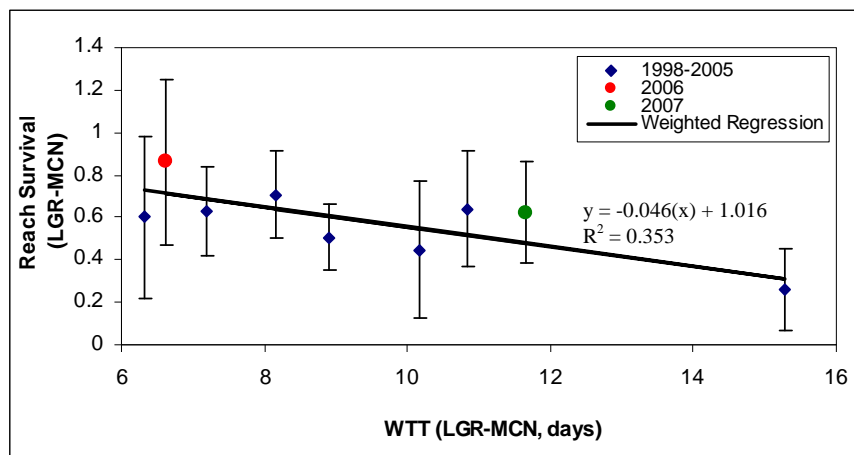
In addition, we estimated the proportion of the Snake River sockeye juvenile population destined to be transported. This estimate was based on the detection probabilities at each of the collector projects. As with the Mid-Columbia, we reviewed hatchery release data for 2006 and 2007, compared to past years. For this analysis, we tallied hatchery releases of sockeye in the Snake River Zone (above LGR) based on their expected year of out-migration. Finally, to address the possibility of straying, we reviewed PIT-tag detections of Mid-Columbia sockeye adults at Ice Harbor and Lower Granite Dam.

Among the migration years analyzed, migration year 2006 resulted in the highest estimate of juvenile survival (LGR-MCN), at 0.86. Migration year 2007 had a reach survival of 0.62, which was relatively high when compared to more recent years (Table 4).

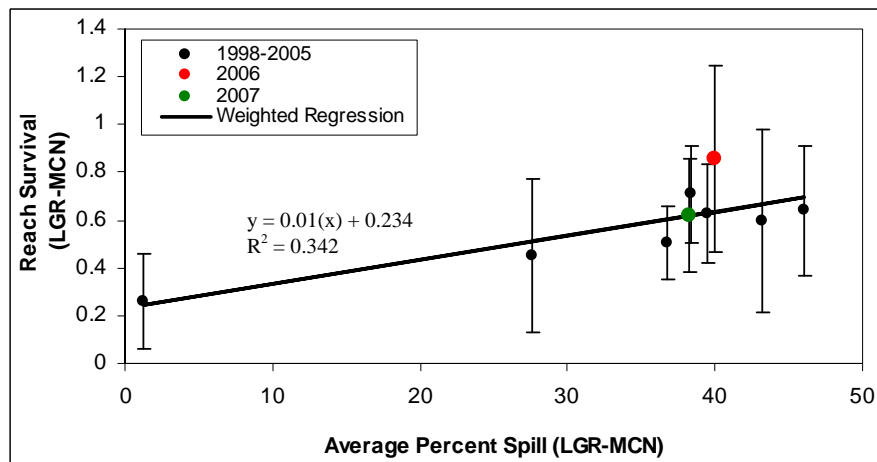
As with the Mid-Columbia sockeye, the high flows and, thus, short water transit times in 2006 likely contributed to the increased reach survival in this year. Weighted regression analyses showed a strong relationship between water transit time and juvenile reach survival (LGR-MCN), where reach survival increases as water transit time decreases (Figure 3). Furthermore, it is likely that average spill percent also contributed to the higher reach survivals in migration year 2006, as higher percent spill resulted in higher reach survivals (Figure 4).

**Table 4.** Juvenile reach survival (LGR-MCN) and in-river conditions experienced by PIT-tagged sockeye juveniles with first time detects at LGR or LGS. Survival estimate to MCN was not possible in migration year 2004 due to a large proportion of PIT-tagged individuals being transported in that year.

Migration Year <sup>A</sup>	Average Flow (Kcfs)	Fish Travel Time (days)	Water Transit Time (days)	Average Spill Percent	Juvenile Survival (LGR-MCN)	95% Confidence Interval	
						Lower Limit	Upper Limit
1998	196.6	10.3	6.3	43.2	0.60	0.22	0.98
1999	173.0	6.4	7.2	39.5	0.63	0.42	0.84
2000	117.0	7.5	10.9	46.1	0.64	0.37	0.91
2001	80.5	12.5	15.3	1.2	0.26	0.06	0.46
2002	147.0	8.6	8.9	36.7	0.50	0.35	0.66
2003	152.6	5.6	8.2	38.4	0.71	0.50	0.91
2004	129.0	6.8	9.7	27.4	N/A	N/A	N/A
2005	121.9	14.3	10.2	27.6	0.45	0.13	0.77
2006	189.9	6.8	6.6	40.0	0.86	0.47	1.25
2007	116.0	8.4	11.7	38.3	0.62	0.38	0.86



**Figure 3.** Weighted regression of water transit time and juvenile reach survival (LGR-MCN) of PIT-tagged Snake River sockeye juveniles released above Lower Granite Dam.



**Figure 4.** Weighted regression of average percent spill and juvenile reach survival (LGR-MCN) of PIT-tagged Snake River sockeye juveniles released above Lower Granite Dam.

Among the years analyzed, migration years 2006 and 2007 resulted in some of the lowest estimates of proportion of juvenile sockeye transported (Table 5). In fact, with exception to 2000, the proportion transported in these two years was substantially lower than the other years analyzed.

**Table 5.** Estimated proportion of Snake River sockeye population “destined” for transport.

<b>Migration Year</b>	<b>Proportion Transported</b>
1998	0.719
1999	0.753
2000	0.518
2001	0.950
2002	0.663
2003	0.758
2004	0.952
2005	0.859
2006	0.592
2007	0.532

Coincidentally, the last year where sockeye adult returns to LGR were above 200 was in 2000 and most of these adults would likely have out-migrated in 1998 and 1999. Of all the years analyzed, 1998 and 1999 had some of the shortest water travel times, highest average percent spill, and highest reach survivals.

Releases of hatchery sockeye to the Snake River have fluctuated over the past 10 years, ranging from 40,419 in 2000 to 335,803 in 1998 (Table 6). Since 2005, hatchery sockeye releases to the Snake River zone have increased to approximately 158,000 to 209,000 juveniles per year.

**Table 6.** Hatchery releases (by migration year) of sockeye smolts and pre-smolts in the Snake River Zone.

<b>Migration Year</b>	<b>Number Released</b>
1998	335,803
1999	151,899
2000	40,419
2001	86,029
2002	144,838
2003	140,410
2004	76,927
2005	209,046
2006	158,160
2007	208,968

At this time, there have been no detections of PIT-tagged Mid-Columbia sockeye adults at Ice Harbor or Lower Granite dams. Therefore, based on PIT-tag detections, there is no evidence of straying of Mid-Columbia sockeye to the Snake River.



Therefore, it is likely that the increased adult returns of Snake River sockeye is likely the result of a combination of good in-river conditions (e.g., low water transit time in 2006 and high spill percent in 2006 and 2007), increased juvenile reach survivals in 2006 and 2007, and low transportation proportions in 2006 and 2007.