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MEMORANDUM

TO: Members' Management Ad Hoc Group

Michele DeHart

FROM: Michele DeHart

DATE: October 14, 2002

RE: Preliminary Update on Juvenile Migration Characteristics

At your request the FPC staff has been working on summarizing the information collected to-date regarding the juvenile migration characteristics observed throughout the Columbia River Basin. This assignment was to prepare the Members for the upcoming Northwest Power Planning Council's Fish and Wildlife Amendment Process. The volume of information we are considering is large and we have not yet completed our analyses. However, at this time we would like to provide a preliminary update regarding the information we have analyzed thus far and a synopsis of what further analyses we have planned.

The analyses are approached in three components, the Snake River, Mid-Columbia and Lower Columbia River reaches. Initially we have focused on the migration characteristics of juvenile salmonids including; travel time (migration speed), survival and migration timing. Subsequent analyses will focus on these migration characteristics and multiple regressions using a suite of biotic and abiotic factors that affect them. The following is an update of each of these migration characteristics and the analyses conducted thus far in our assignment.

Travel Time

The juvenile migrants considered for these analyses represent groups for which travel time and survival was estimated for the entire Lower Granite to McNary reach using PIT tag technology. The first year that PIT tag data was available for the entire Lower Granite to McNary reach was 1995, coincident with the installation of sufficient lower Columbia PIT tag detectors to allow the reliable estimation of survival to McNary Dam. PIT tag studies were initiated as soon as the PIT tag detection units were installed at the projects. In 1993 studies could only be conducted between Lower Granite and Little Goose dams. This was expanded to the Lower Granite to Lower Monumental River reach when PIT tag detectors were installed at additional projects. The detection limitations of the early years necessitated the extrapolation of the shorter river reach survival estimates to the longer reach (Lower Granite to McNary). We now know that these earlier estimates using extrapolation resulted in a mis-representation of survival when applied to the longer reach. Consequently, we have chosen not to include these estimates in our analysis. In addition, the 1997 migration was characterized by a small juvenile population. Few fish were marked and, therefore, estimation of survival was not possible. This year was eliminated from the analysis for that reason. Steelhead data for 1995 is not available since insufficient numbers of fish were marked that year to yield estimates of survival.

Travel time is the amount of time needed for juvenile migrants to transit the river system between any two points. The correlation between smolt migration rate and water velocity was established in early data analysis and identified river flow as a key factor in determining how quickly smolts migrated through the hydrosystem. It is always difficult to represent the flow variable as a succinct quantity experienced by any group of migrating juvenile fish. Past efforts have used an index flow through a specific reach for a period of time around the median passage dates of a group of fish or an average flow over the entire passage period. Because of the discrete relation between flow and water transit time (also known as water particle travel time) we chose to quantify the flow variable as the summation of water transit times for each reservoir incorporated in a reach. The analyses we have conducted thus far have focused on the Snake River hydrosystem reach that is for the migration from the tailrace of Lower Granite Dam to McNary Dam. Water transit time was used to characterize flow for each release group originating at Lower Granite Dam. The median travel time was estimated to each down stream project for each weekly block. We then used the mid-date of release from LGR, added median travel time for the release group to the downstream project, and added 3 days on each side of that date to determine the ‘reference’ passage date range for the release group. We then used average total discharge and average forebay elevation during that passage date range to determine reservoir volume at time of passage. Subsequently, volume/average total discharge was used to calculate water transit time.

There is a close relation between the water transit time and the corresponding flow as evidenced in the following graphic representations for the Snake River groups (Figure 1).

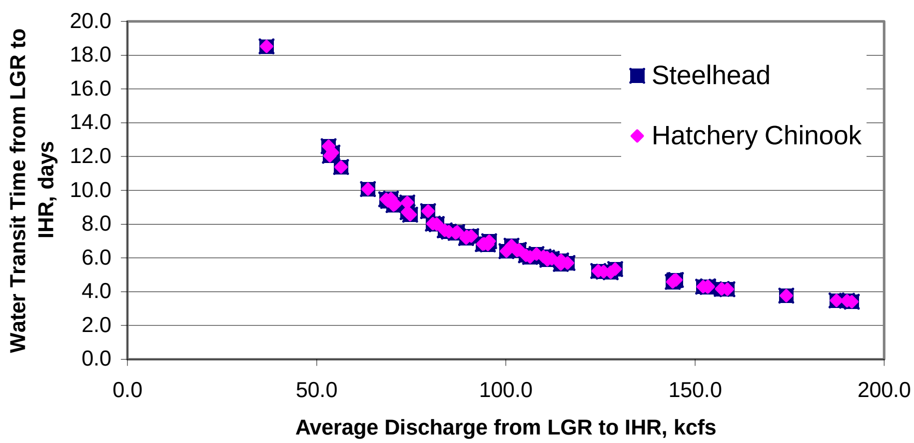

Figure 1. Relation between water transit time and flow for Snake River hatchery chinook and steelhead.

For this preliminary analysis of the data the relations were modeled using linear regression. Subsequent analyses may incorporate alternate relations that may better explain the relation between, and among, the variables. However, using simple linear regression models we obtained the following relations for wild yearling chinook (Figure 2), hatchery yearling chinook (Figure 3) and steelhead (wild and hatchery)(Figure 4) originating above Lower Granite Dam and migrating between the tailrace of Lower Granite Dam and McNary Dam.

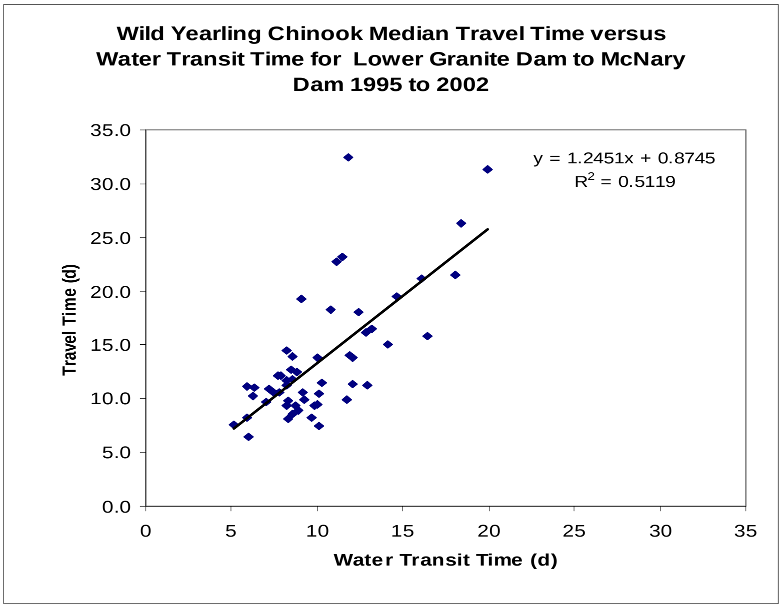

Figure 2. Wild Yearling Chinook travel time versus water transit time.

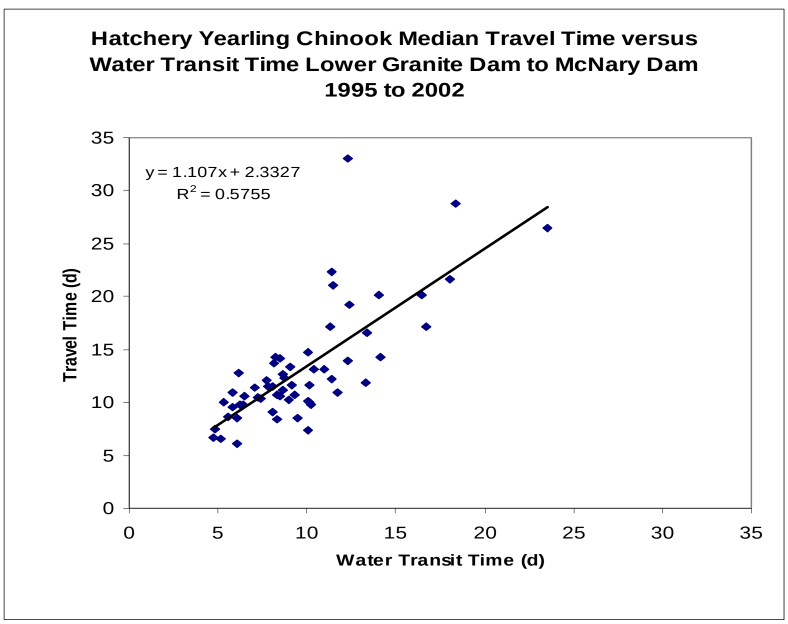

Figure 3. HatcheryYearling Chinook travel time versus water transit time.

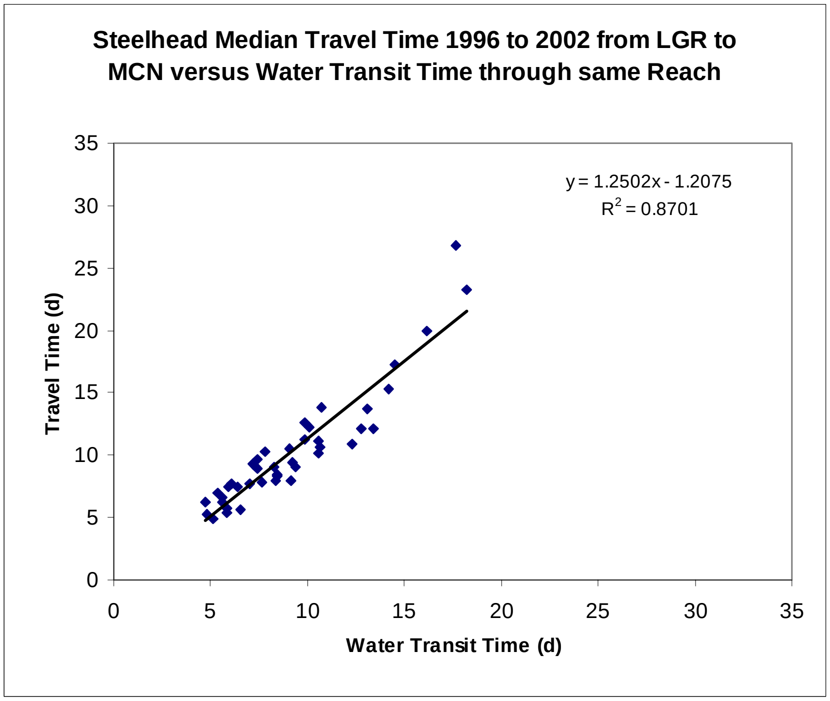

Figure 4. Steelhead travel time versus water transit time

Table 1. Summary of linear regressions of median travel time versus water transit time for wild and hatchery chinook and steelhead.

Group	Regression Equation	Correlation Coefficient (R^2)
Wild Chinook	y = 1.245x + 0.8745	0.5119
Hatchery Yearling Chinook	y = 1.107x + 2.3327	0.5755
Steelhead	y= 1.250x + 1.2075	0.8701

A comparable analysis of the travel time in the Rock Island Dam to McNary Dam index reach has not yet been completed. However, as we reported in the Fish Passage Center's 2001 Annual Report, the annual average travel time for yearling chinook in the Mid-Columbia River index reach was between 12 and 14 days in the 1999 to 2000, and was at least 60% longer in 2001 at an average of 22.3 days (Figure 5). The steelhead annual average travel time estimates was just under 7 days in 1999 and 2000, and was approximately 150% longer in 2001 at an average of 17.4 days (Figure 6). Mid-Columbia River springtime flows indexed at Priest Rapids Dam averaged below 85 kcfs in 2001, compared to seasonal averages well above 140 kcfs in the other two years. Consequently, we anticipate that the same relations between water transit time and travel time will likely result when we undertake the analysis.

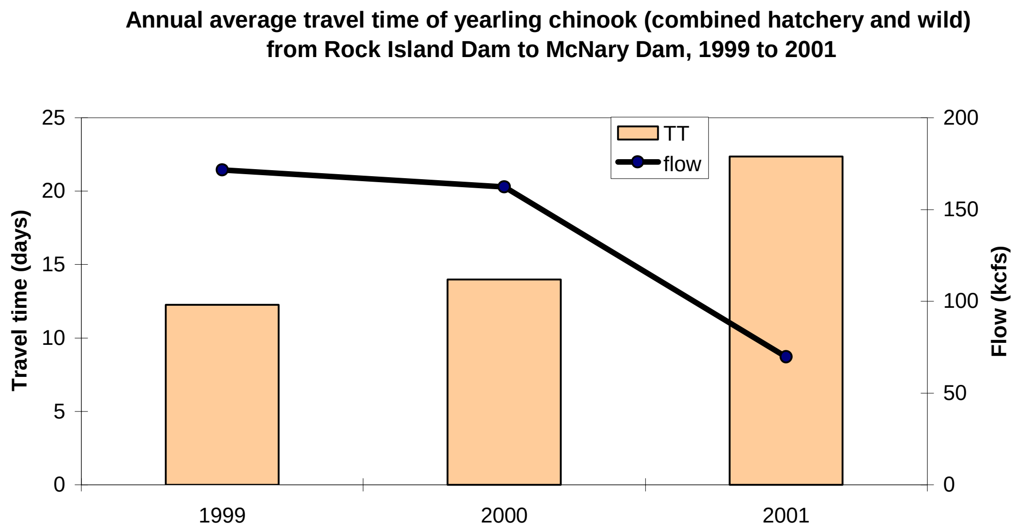

Figure 5. Annual average travel time of yearling chinook from Rock Island Dam to McNary Dam in 2001 compared to 1999 – 2000.

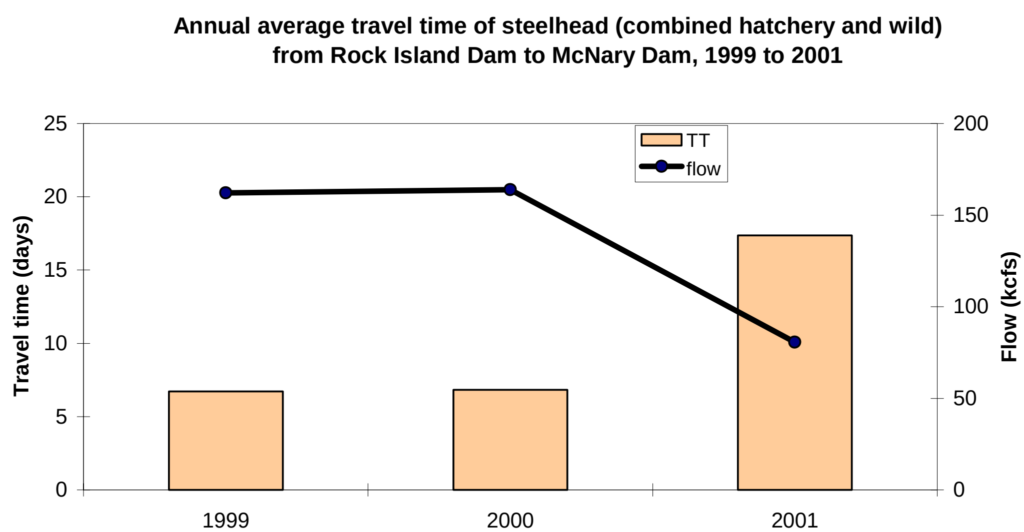

Figure 6. Annual average travel time of steelhead from Rock Island Dam to McNary Dam in 2001 compared to 1999 – 2000**.**

In summary, we have described the relation between water transit time and flow, which is statistically significant ($P<0.01$) for all groups described above.

Survival

The survival of wild chinook, hatchery chinook and steelhead was estimated from the tailrace of Lower Granite Dam to the tailrace of McNary Dam for the same groups used in the travel time analysis. Prior to 2001, the year characterized as having the second lowest runoff volume on record, the survival estimates had been obtained in years that the Biological Opinion flow objectives were mostly met. Consequently, it was difficult to demonstrate a flow survival relation. However, the addition of the 2001 data has defined the survival/flow relation that occurs when flows are below the Biological Opinion flow objectives. The following graphs show the relation between water transit time and survival for wild yearling chinook (Figure 7), hatchery yearling chinook (Figure 8) and steelhead (Figure 9).

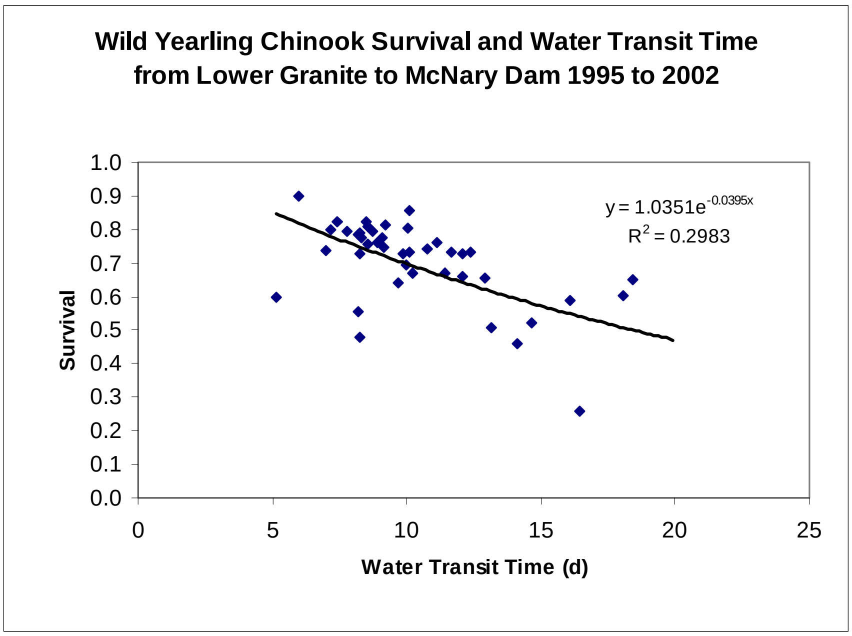

Figure 7. Water Transit time versus survival for wild yearling chinook.

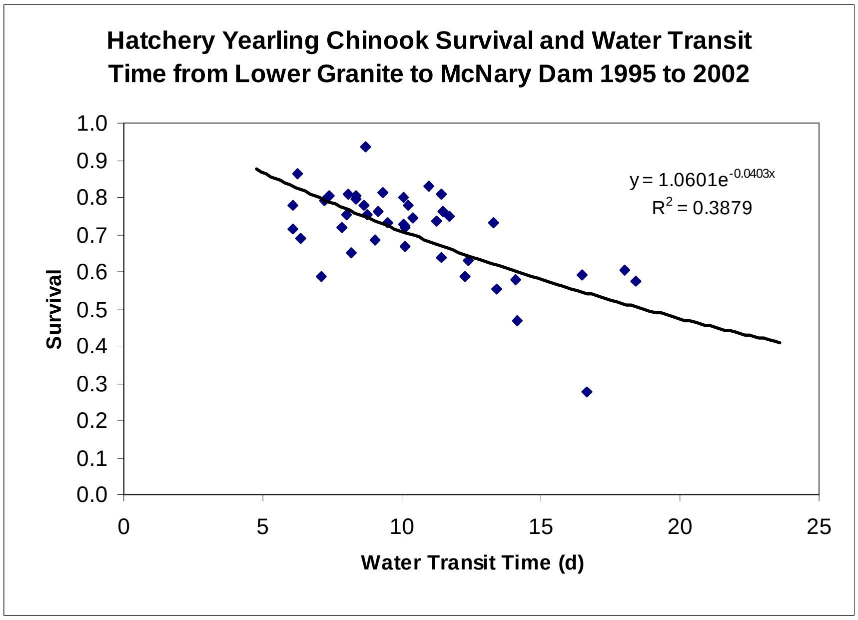

Figure 8. Water Transit time versus survival for hatchery yearling chinook.

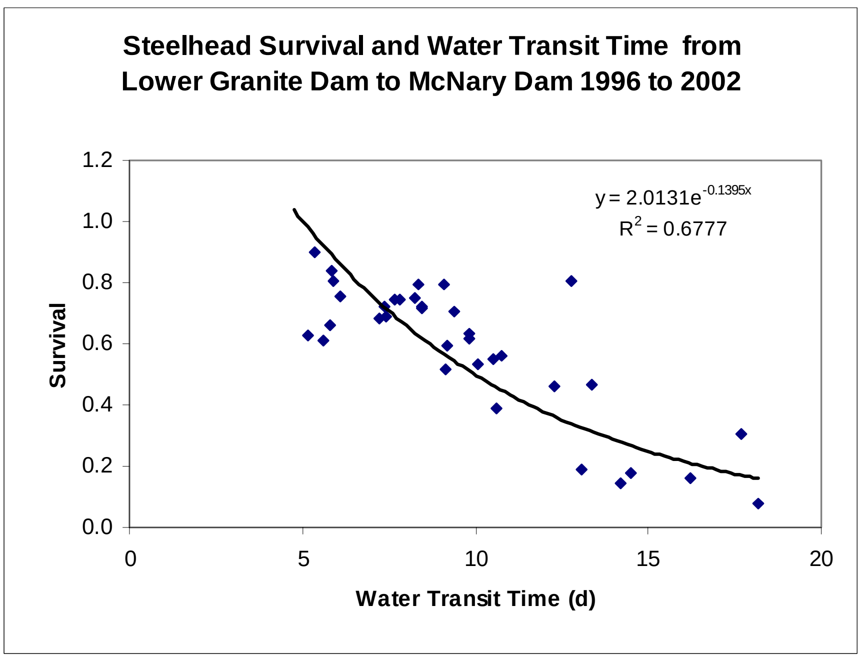

Figure 9. Water Transit time versus survival for steelhead.

Table 2. Summary of regressions for water transit time versus survival for wild and hatchery chinook and steelhead.

Group	Regression Equation	Correlation Coefficient (R^2)
Wild Chinook	$y = 1.035e^{-0.039x}$	0.2983
Hatchery Yearling Chinook	$y = 1.060e^{-0.0403x}$	0.3879
Steelhead	$y = 2.013e^{-0.1395x}$	0.6777

In summary, the low flows experienced in 2001 allowed us to describe a portion of the relation between flow and survival in the Snake River Reach that had not previously been possible. From our analyses thus far we have demonstrated the relation between flow and water transit time, water transit time and travel time and subsequently between water transit time and survival. The relation between water transit time and survival is statistically significant ($P < 0.01$) suggesting that flow by itself can be used in the bivariate relations to explain a significant portion of the variability in survival. We recognize that there are additional factors that affect juvenile survival and plan to further analyze our data to determine if these variables could help explain the additional variability that cannot be explained by the flow variable alone.

We have not yet analyzed the Mid-Columbia or Lower Columbia data to the extent that the Snake River has been reviewed. However, data contained in the Fish Passage Center's 2001 Annual Report fully support the notion that similar results would be obtained for fish migrating through these two river reaches; Rock Island Dam to McNary Dam tailrace index reach and the McNary Dam tailrace to Bonneville Dam tailrace index reach.

The 2001 seasonal average survival estimates for fish PIT tagged (mixture of hatchery and wild fish) and released from Rock Island Dam to the tailrace of McNary Dam were 55.2% for yearling chinook and 18.6% for steelhead (Figures 10 and 11). These survival estimates were lower than in the previous three years, with the most dramatic drop in survival occurring for steelhead. Steelhead's 2001 survival estimate was over 200% lower than in the prior three years.

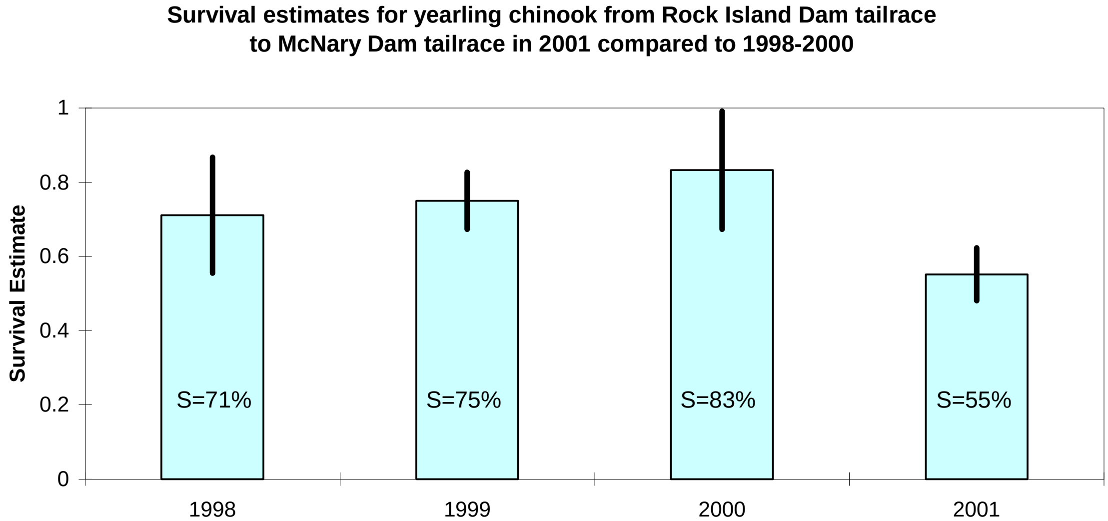

Figure 10. Estimated annual survival for yearling chinook from Rock Island Dam tailrace to McNary Dam tailrace in 2001 compared to 1998 – 2000.

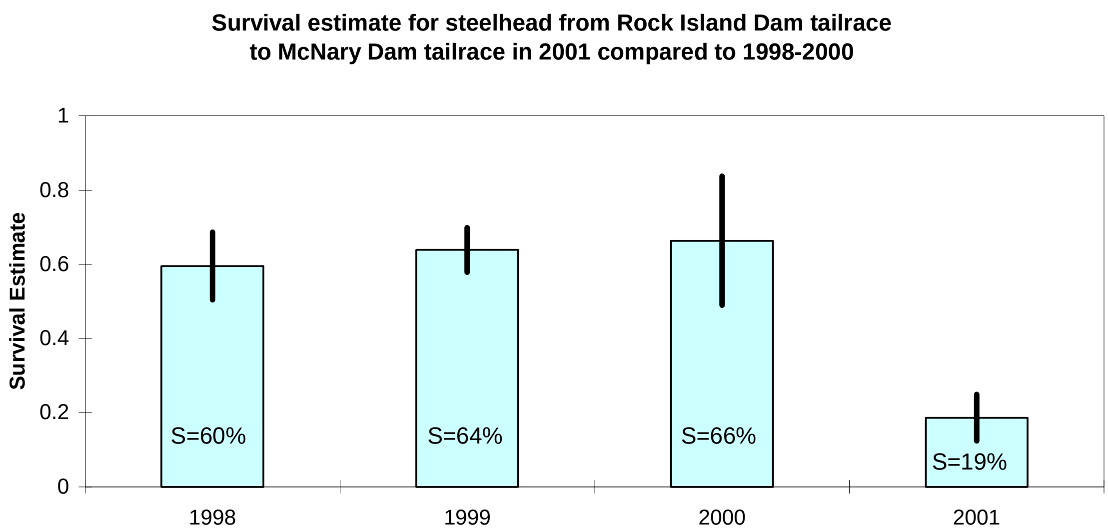

Figure 11. Estimated annual survival for steelhead from Rock Island Dam tailrace to McNary Dam tailrace in 2001 compared to 1998 – 2000.

The annual average survival of combined wild and hatchery yearling chinook and steelhead in the index reach from McNary Dam tailrace to Bonneville Dam tailrace (*i.e.*, lower Columbia River index reach) in 2001 was 53% for yearling chinook and 23% for steelhead (Figure 12). This annual survival estimate was 17% lower for yearling chinook than what NMFS reported for 2000, and 60% lower for steelhead. The PIT tag data used to estimate survival in the lower Columbia River included smolts from both the Snake River and Mid-Columbia River basins, however, most untagged smolts migrating in-river between McNary and Bonneville dams in 2001 were of Mid-Columbia and lower Columbia River origin.

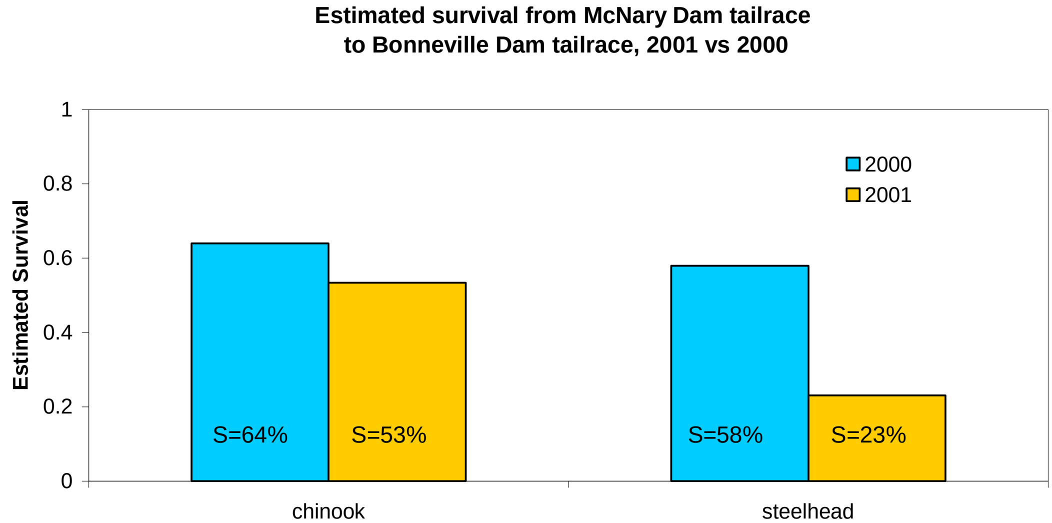

Figure 12. Estimated annual survival of in-river migrating PIT tagged yearling chinook and steelhead from McNary Dam tailrace to Bonneville Dam tailrace in 2001 compared to NMFS estimates of annual survival in 2000.

Migration Timing

The population of juvenile salmon is not homogeneous throughout the entire migration season. Consequently, the concept of migration timing is extremely important in fish management. Some fish migrate in discrete time periods that may be significantly different from the timing displayed by the migration as a whole. We observed PIT tagged yearling chinook and steelhead at John Day Dam in 2001 and quantified their timing in the Lower Columbia River. Yearling chinook and steelhead stocks that originated in the Walla Walla, Umatilla and John Day rivers are the earliest stocks to pass John Day Dam in 2001. In 2001, the percent of PIT tagged yearling chinook from the John Day and Umatilla rivers detected at John Day Dam in April was approximately 53% and 13%, respectively (Table 3), whereas virtually no PIT tagged yearling chinook from the Snake and Mid-Columbia River basins were detected until May. The percent of PIT tagged steelhead from the John Day and Umatilla rivers detected at John Day Dam in April was approximately 31% and 11%, respectively (Table 4), and again virtually no PIT tagged steelhead from the Snake and Mid-Columbia River basins were detected until May.

Table 3. Proportion of PIT tagged yearling chinook detected at John Day Dam over specific periods of the 2001 migration season.

Dates of PIT tag detections at John Day Dam	Snake R basin	Mid-Columbia R basin at/above Rock Island Dam[1]	Yakima R basin	Umatilla R basin	John Day R basin
Total detections	14,086	2,091	4,041	1,291	1,743
3/30 – 4/30	0.0002	0.0000	0.0084	0.1332	0.5295
5/1 – 5/24	0.3369	0.1836	0.3606	0.7854	0.4509
5/25 – 6/15	0.5422	0.6738	0.5048	0.0736	0.0132
6/16 – 9/15	0.1207	0.1425	0.1262	0.0077	0.0063

[1] PIT tagged hatchery chinook released on alternating days at Rock Island & Rocky Reach dams in large numbers for specific studies were omitted because they do not represent the timing of the run-of-the-river fish.

Table 4. Proportion of PIT tagged steelhead detected at John Day Dam over specific periods of the 2001 migration season.

Dates of PIT tag detections at John Day Dam	Snake R basin	Mid-Columbia R basin at/above Rock Island Dam	Walla Walla R basin	Umatilla R basin	John Day R basin
Total detections	440	59	23	1,005	97
3/30 – 4/30	0.0045	0.0000	0.0000	0.1124	0.3093
5/1 – 5/24	0.4841	0.1525	0.8696	0.7532	0.6082
5/25 – 6/15	0.3886	0.5254	0.0870	0.1085	0.0825
6/16 – 9/15	0.1227	0.3220	0.0435	0.0259	0.0000

Preliminary Conclusions

We are presenting you with this information to update you on our ongoing analysis to-date. The results presented here are drawn from nearly one million PIT tagged juvenile salmonids migrating during the years discussed. Several preliminary conclusions can be drawn from these analyses including:

- Travel time is significantly related to water transit time, which is a function of flow, for the groups examined.
- Based on the relation between flow and water transit time, the 85 to 100 Kcfs 2000 Biological Opinion flow objective provides water transit times that vary in magnitude less than they vary below 85 Kcfs.
- Based on the data collected to-date flow objectives are necessary to assure juvenile survival.
- Modification to spring flow objectives through the alteration of reservoir operations from those specified in the Biological Opinion would likely decrease the survival of juvenile salmonids.