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MEMORANDUM

TO: Paul Wagner, NOAA Fisheries

FROM: FPC Staff

DATE: June 22, 2006

RE: Trends in Travel Time of subyearling Chinook in the McNary Dam to Bonneville Dam during July and August

You requested that the FPC revisit the information that was used to develop the fall Chinook flow travel time relationship for the lower Columbia River. In your email request (June 15, 2006) you stated, "The prior data was a seasonal relationship that I believe was based on freeze branded fish primarily from the Hanford reach. PIT tag data should be able to put a finer point on this relationship and could allow the data to be partitioned into monthly groups: July and August. I think a finer cut on this data may better reflect the behavior of fish as the season progresses i.e. early in the season the fish are rearing and migrating while later in the season they are more directed migrants. It would be nice to know if this was the case."

In response to your request, we analyzed subyearling Chinook travel time data to determine what trends were occurring in July and August in the Lower River Columbia River reach from McNary Dam to Bonneville Dam. We attempted to use data from Snake River origin wild fish but found there were too few tag detections available to allow comparison across July and August through the reach. Instead we compared travel times of Snake River Hatchery subyearling Chinook and travel times of subyearling Chinook marked and released at McNary Dam during recent years (Table 1). We determined that detection data were only adequate for the years 1998, 1999, 2001 and 2002.

The important findings of this analysis were:

- Travel time for July and August migrating Snake River origin subyearling Chinook showed a significant relationship with flows in the McNary to Bonneville Dam reach.

- Your initial suggestion, that fish in August may travel faster because they are more directed migrants does not appear to be true. Snake River fish travel times during August, were longer than those measured in July, in two of the three years of available data (1998 and 2002), reflecting the effects of lower flows during the late season. In the third year, 1999, travel times did not vary significantly through July and August, and that was a year in which July and August flows varied less than in 1998 and 2002.

- BiOp flow targets in the lower Columbia River for summer are set at 200 Kcfs. Based on our predicted relationship, travel times at or above the flow target would average about 5 days for the Snake River hatchery subyearling Chinook, while travel times increase at flows less than the flow target and would double at 110 Kcfs.

- We examined PIT-tag data from 1998 to 2005 for Snake River subyearling Chinook travel time data for fish PIT-tagged detected at McNary Dam during July and August; we found the most tag data was available for the years 1999, 2001, and 2002.

- Fish released at McNary Dam were also analyzed to provide more data on July and August travel times. Fish were marked in July mostly, with one year having August releases. In that year, 2002, travel times increased (although not significantly due to wide confidence intervals), during the August release similar to the Snake River origin migrants, again reflecting lower flows.

For purposes of this analysis the wild Snake River subyearling data were too sparse to provide useful information on changes in travel time through July and August. In the absence of data on the wild fish, hatchery origin PIT-tagged subyearling fall Chinook were used as a substitute. Even with the additional data available from these fish, there were few detections at Bonneville Dam during the late August time period. The other group for which there was adequate July detections (and limited August data in 2002) were subyearling Chinook marked at McNary Dam. These fish likely were predominantly from the Hanford Reach, but also might represent hatchery and wild origin fish from the Mid-Columbia River to a lesser extent. The rearing-type of the PIT-tagged fish were designated unknown origin by NOAA marking crews. All the marking of these fish occurred in June and July, except in 2002, when fish were marked until Mid-August (see Table 1 for numbers of PIT-tagged observations available for each year and time period). Therefore analysis of travel time is limited with regard to August travel times to that single year for fish marked at McNary Dam.

In our analysis we compared trends in median travel time through time and also regressed travel time versus flow (mean daily discharge in kcfs at John Day Dam, JDA, for each year) across all years (1998,1999 and 2002) using the Snake River hatchery fall Chinook and found a significant relationship between travel time and the inverse of flow. Our analyses suggest that

Snake River origin subyearling Chinook travel time was affected by flows throughout July and August. The longer travel times seen in August were likely explained by decreasing flows during that time period.

To compare travel time during July and August, we grouped PIT-tagged fish into two-week time blocks based on observation or release date at McNary Dam. We used detection at Bonneville Dam to estimate travel time both for individual fish as well as median travel times for each block. The data were also plotted by date for individual fish with trend lines showing general pattern in travel times while the medians for each block were plotted showing 5% and 95% bounds (Figures 1 – 6).

Table 1. Sample sizes for different groups of subyearling Chinook used in our analysis.

			Two-week blocks				
Year	**PIT-tag Origin**	**W/H**	**July 1-15**	**July 16-31**	**Aug 1-15**	**Aug 16-31**	**Total**
1998	Snake	Hatchery	10	131	43	29	213
1998	Snake	Wild	0	6	1	2	9
1999	McNary	H/W	1490	311	0	0	1801
1999	Snake	Hatchery	21	6	22	4	53
1999	Snake	Wild	4	2	0	0	6
2001	McNary	H/W	295	430	0	0	725
2002	McNary	H/W	443	92	36	0	571
2002	Snake	Hatchery	67	42	4	6	119
2002	Snake	Wild	11	7	0	0	18

In 1998 and 2002, the hatchery origin fall Chinook from the Snake River showed longest median travel times in the latest time period, based on the two-week blocks, although sample sizes and variability in the data made estimated travel times not significantly different between time periods. In 1999 travel times were similar through time reflecting relatively similar flow conditions through that year.

In the case of subyearling Chinook tagged and released at McNary Dam, in two of three years analyzed, travel times increased or remained relatively flat from early July to the last block for these fish. The major exception was for plots of 2001 data. In that year, travel times appear to decrease in the first half of August. However, caution should be used in interpreting the 2001 data since it is likely that both mortality and cessation of migration or truncation, could have affected the measured travel times. In other words due to low flows and lateness of the season it is likely that slow moving fish either did not survive to Bonneville Dam or simply stopped migration as travel times were excessively long in that reach.

Finally, using the Snake River hatchery origin subyearling Chinook we generated a predictive line based on travel time and inverse flow with the resulting equation Travel Time = 0.16 + 1042.35 x Discharge^{-1} (R^2 = 0.49). Figure 7 shows the trend line predicting a decrease in travel time as flows increase in the Lower Columbia River. We also plotted wild Snake River subyearling Chinook travel times from the years 1998, 1999, and 2002 along with the hatchery origin data for comparison. It appears that the wild origin fish travel times are similar to hatchery origin fish with respect to their response flow during the July-August time period.

In conclusion, based on the available data our analyses suggest that Snake River origin subyearling Chinook travel time is a function of flows throughout July and August. The longer travel times observed for fish migrating in August are likely explained by lower flows during that time period. Decreasing flows lower than the BIOP flow target would be expected to translate into increasing travel times for subyearling migrants in the lower River.

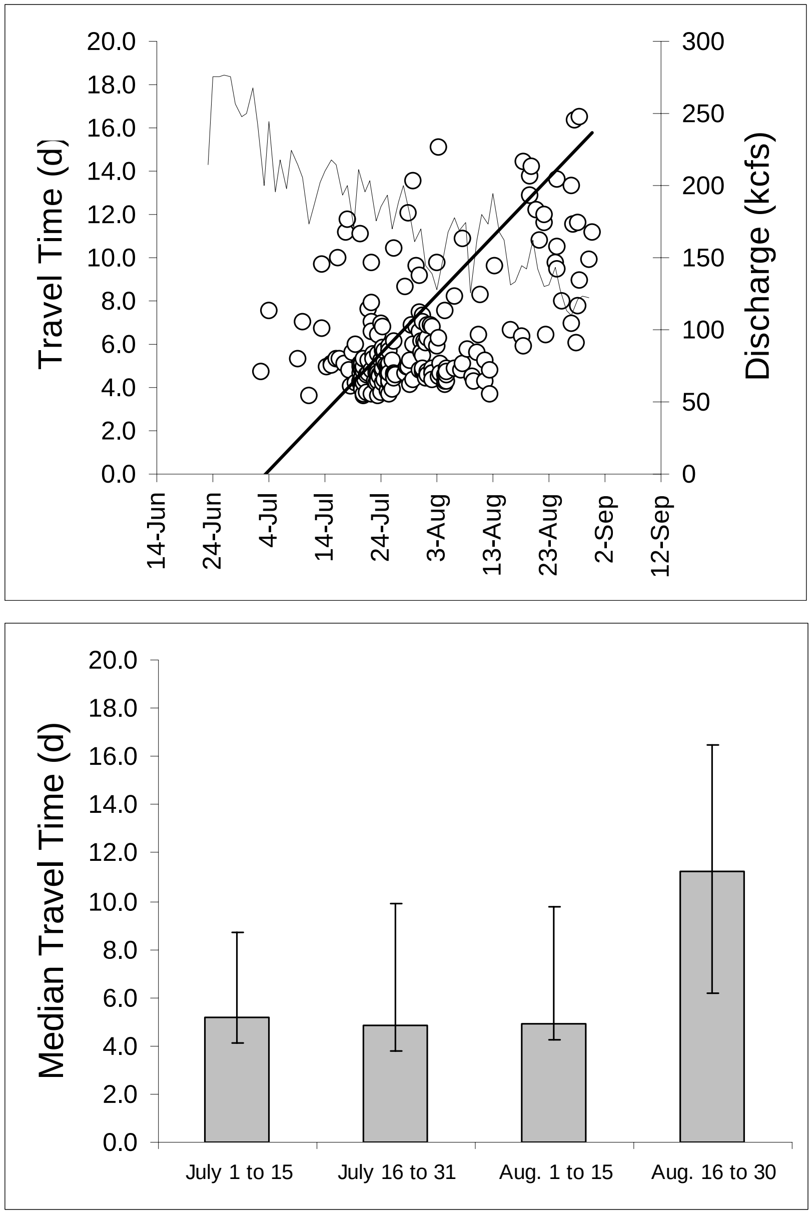

Figure 1. Scatter plot of individual subyearling Chinook salmon (from Snake River Hatcheries) travel times from McNary to Bonneville dams (dots) and discharge at JDA (line) across the 1998 migration season (Upper Panel) and bar chart of median travel time (-/+ 5th and 95th percentile bounds) for 4 time periods (Lower Panel). See Table 1 for sample sizes and comments.

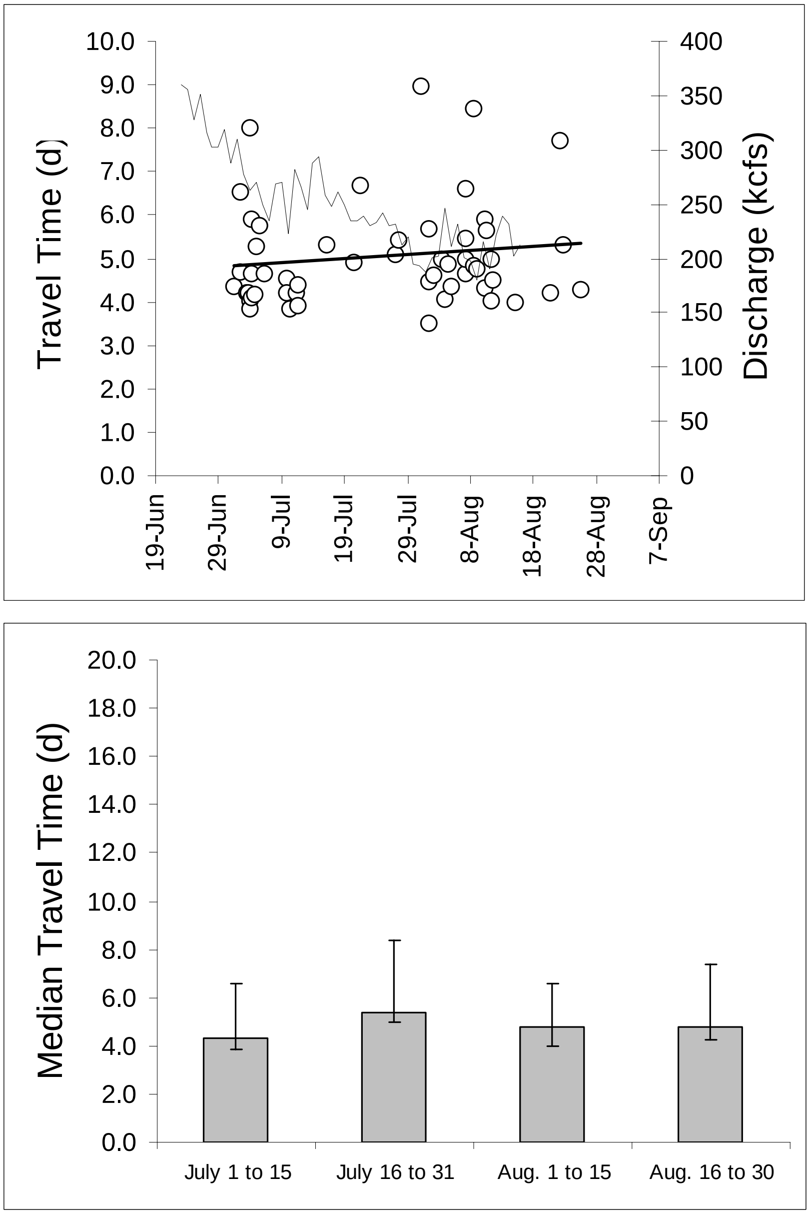

Figure 2. Scatter plot of individual subyearling Chinook salmon (from Snake River Hatcheries) travel times from McNary to Bonneville dams (dots) and discharge at JDA (line) across the 1999 migration season (Upper Panel) and bar chart of median travel time (-/+ 5^{th} and 95^{th} percentile bounds) for 4 time periods (Lower Panel). See Table 1 for sample sizes and comments.

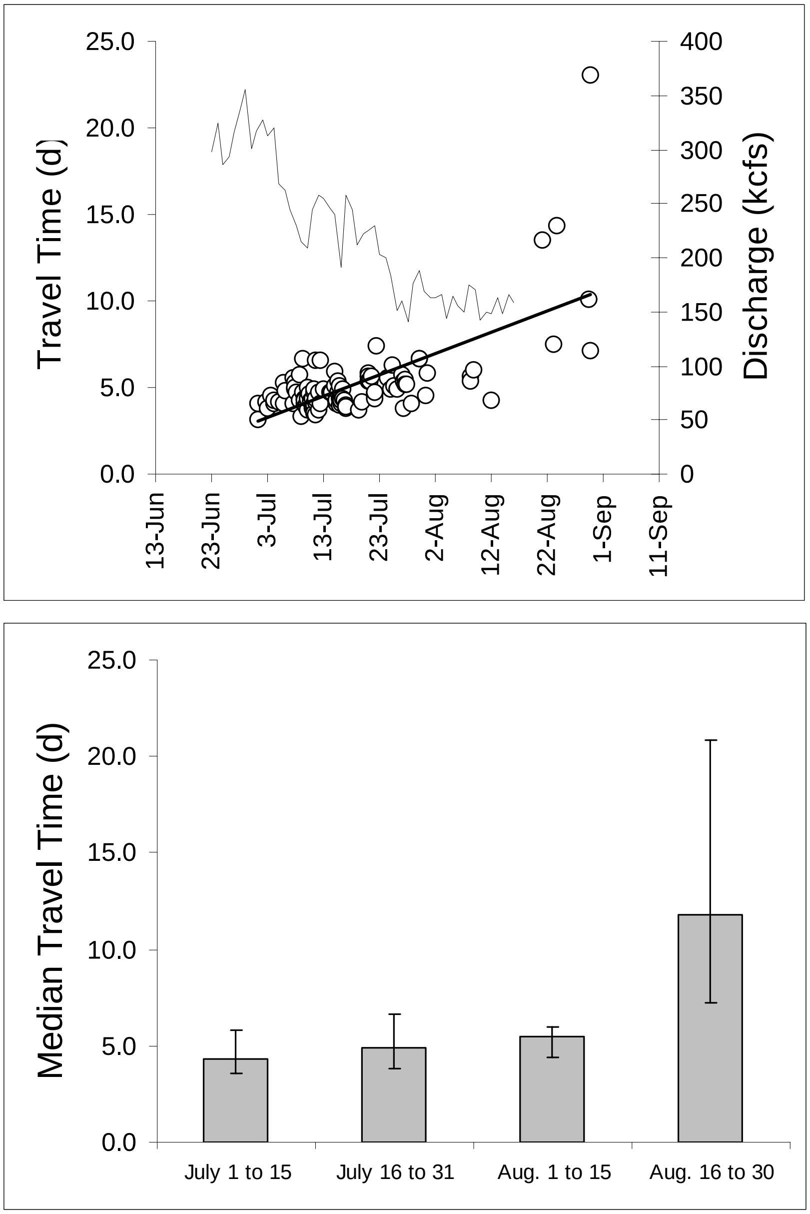

Figure 3. Scatter plot of individual subyearling Chinook salmon (from Snake River Hatcheries) travel times from McNary to Bonneville dams (dots) and discharge at JDA (line) across the 2002 migration season (Upper Panel) and bar chart of median travel time (-/+ 5th and 95th percentile bounds) for 4 time periods (Lower Panel). See Table 1 for sample sizes and comments.

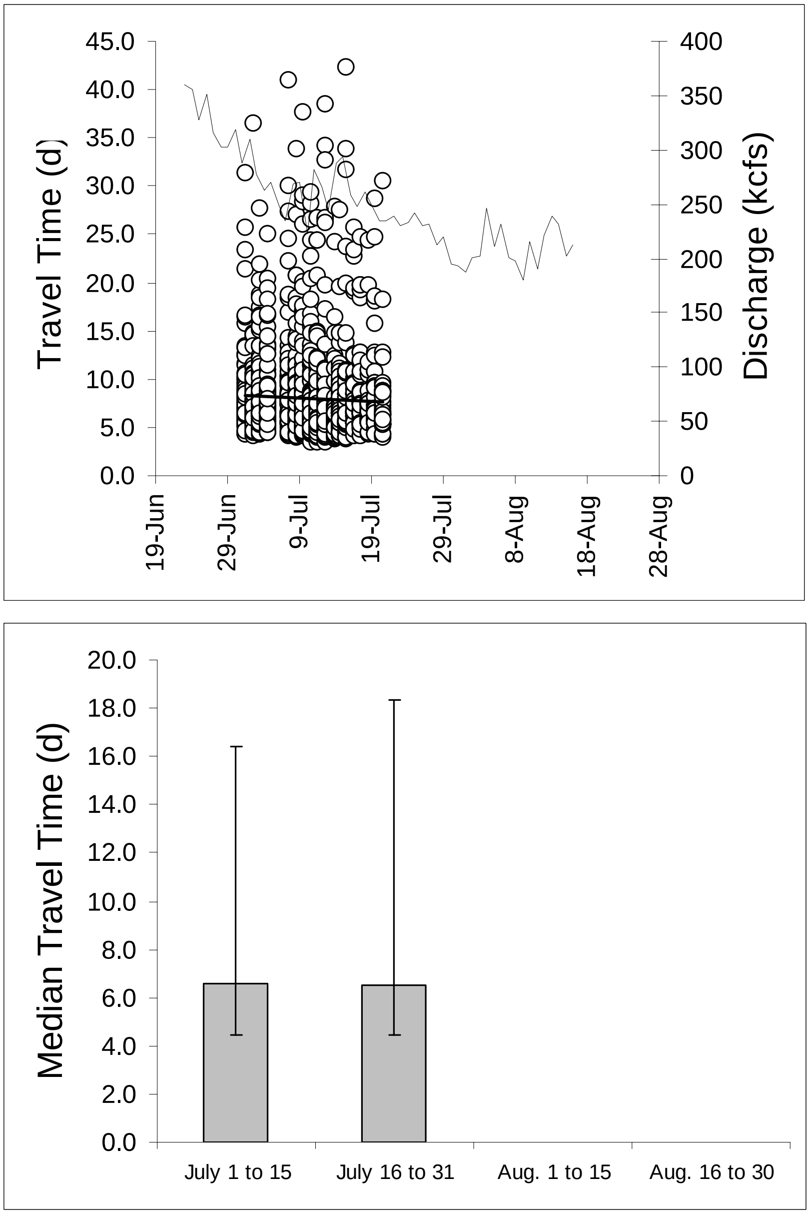

Figure 4. Scatter plot of individual subyearling Chinook salmon (marked and released at McNary Dam) travel times from McNary to Bonneville dams (dots) and discharge at JDA (line) across the 1999 migration season (Upper Panel) and bar chart of median travel time (-/+ 5th and 95th percentile bounds) for 4 time periods (Lower Panel). See Table 1 for sample sizes and comments.

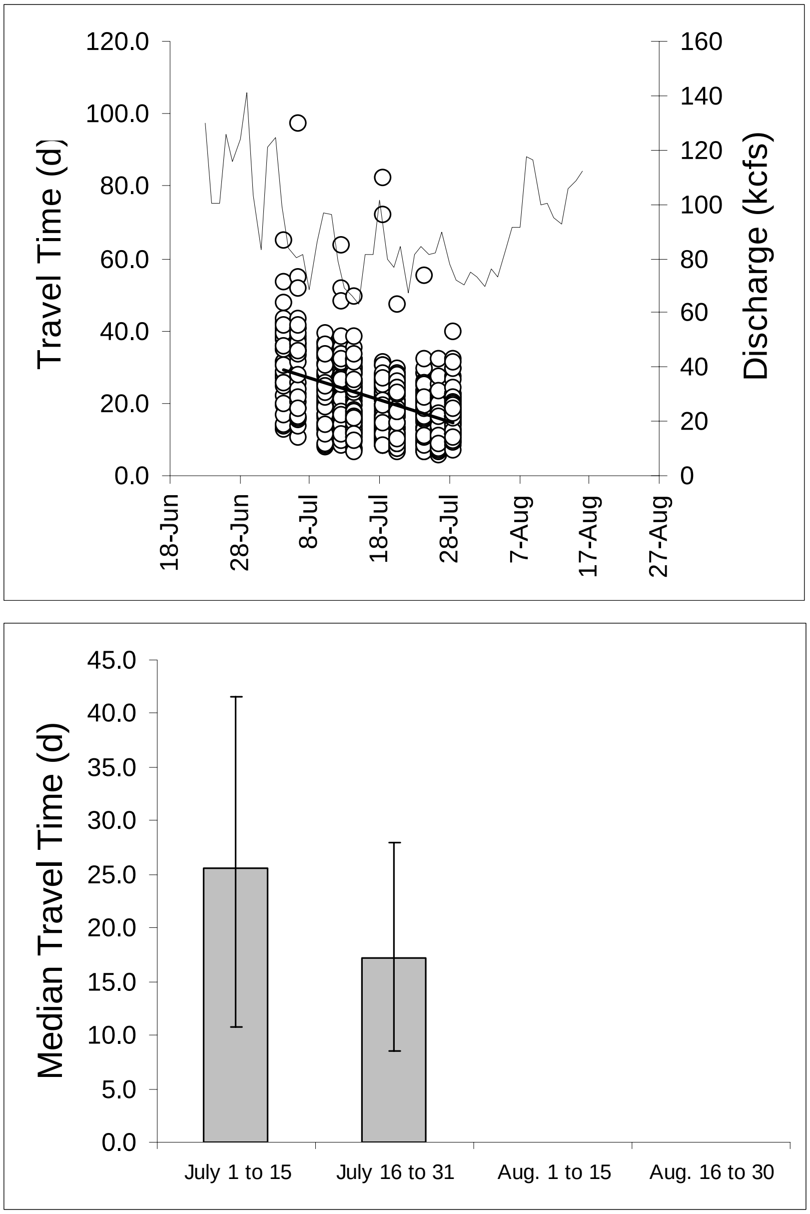

Figure 5. Scatter plot of individual subyearling Chinook salmon (marked and released at McNary Dam) travel times from McNary to Bonneville dams (dots) and discharge at JDA (line) across the 2001 migration season (Upper Panel) and bar chart of median travel time (-/+ 5th and 95th percentile bounds) for 4 time periods (Lower Panel). See Table 1 for sample sizes and comments.

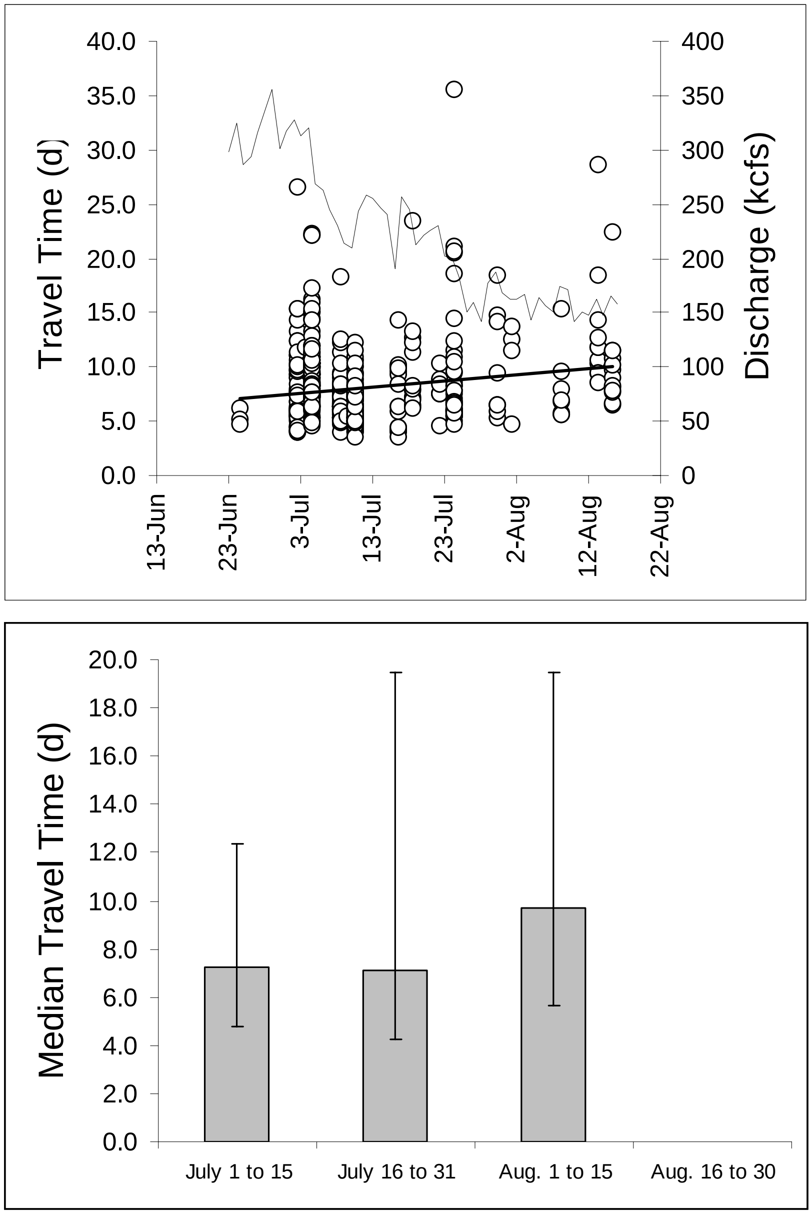

Figure 6. Scatter plot of individual subyearling Chinook salmon (marked and released at McNary Dam) travel times from McNary to Bonneville dams (dots) and discharge at JDA (line) across the 2002 migration season (Upper Panel) and bar chart of median travel time (-/+ 5th and 95th percentile bounds) for 4 time periods (Lower Panel). See Table 1 for sample sizes and comments.

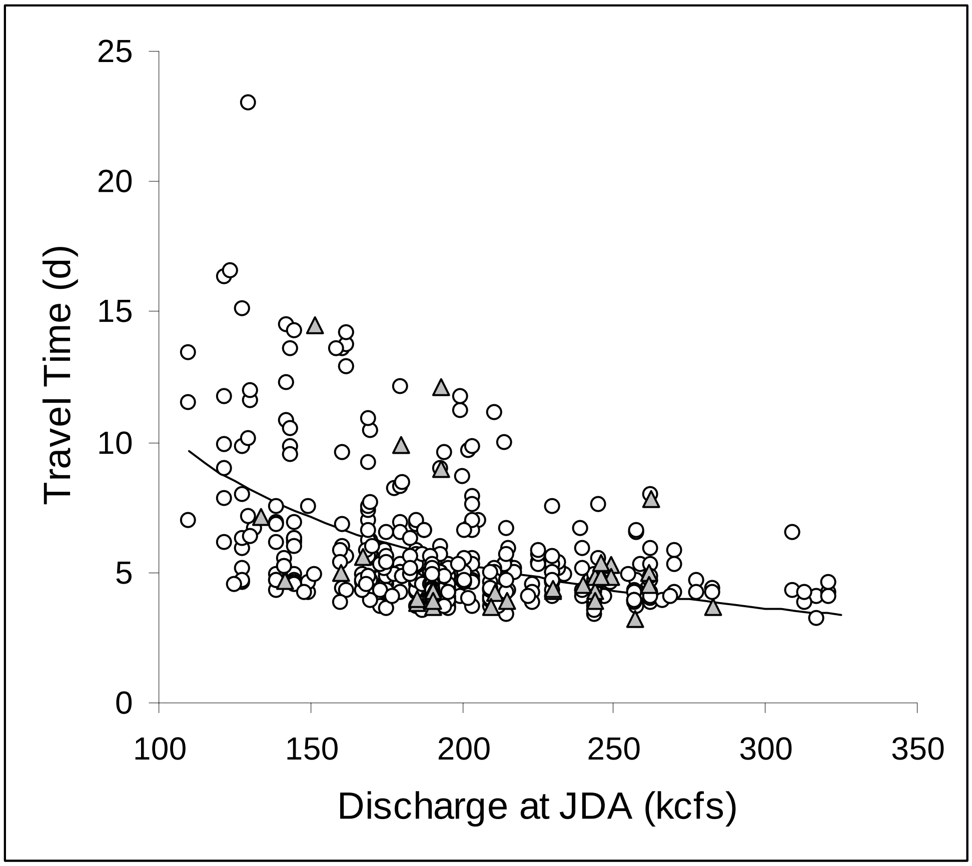

Figure 10. Flow-travel time from (McNary to Bonneville dams) plot for hatchery (white circles) and wild (gray triangles) Snake River fall Chinook salmon subyearling migrants across years queried with sufficient detections (1998, 1999, 2002). Equation of the best-fit line (for hatchery origin fish) is Travel Time = 0.16 + 1042.35 x Discharge^{-1} (R^2 = 0.49).