# ANALYSES OF JUVENILE CHINOOK SALMON AND STEELHEAD TRANSPORT FROM LOWER GRANITE AND LITTLE GOOSE DAMS, 1998-2008

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Northwest Fisheries Science Center

Fish Ecology Division

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Executive Summary

- The report provides analyses of patterns of smolt-to-adult return rates (SARs) relative to in-season migration timing of smolts. SARs of juvenile fish that were transported from either Lower Granite Dam (LGR) or Little Goose Dam (LGO) were compared to SARs of non-transport fish that migrated through the lower Snake and Columbia Rivers in the years 1998 – 2008.

- The measure used to assess the benefit of transport relative to downstream migration was the transport to migrant ratio (T:M), defined as the ratio of SAR for transported fish to that of non-transport migrants for corresponding groups. Statistical models produced estimated values for the SARs of the two groups and the T:M for each day was estimated from those estimates.

- To study seasonal SAR patterns required known dates of juvenile passage. Therefore, migrant groups were formed from PIT-tagged fish that were bypassed (i.e., detected) at the collector dams. The value of information from bypassed migrants has been discounted by some scientists in the region because bypassed fish generally have lower SARs than fish that pass the collector projects undetected via non-bypass routes (mostly over the spillway, with a small proportion through turbines). During periods of transport, migrants among the non-tagged run-at-large mostly pass via non-bypass routes (bypassed non-tagged fish are mostly transported), so extrapolation of results for bypassed migrants to the run at large could be biased (estimated T:M ratios greater than would have occurred for the run at large). The report addresses this potential bias by carefully considering standards for comparison of SARs and T:M (detailed below).

- Over the years, fish have been PIT tagged both upstream from LGR and at LGR. Tagging location was included as a potential factor in the models of SAR. In some cases where data were available from both tagging locations, SARs were not statistically different between tagging locations. In other cases, SARs differed significantly but relative SARs between transport and migrant fish (i.e., T:M ratio) were the same. In still others, both SARs and T:M differed depending on tagging location.

- The basic unit of data on which the analyses were based was the estimated SAR for a daily group of fish. Each LGR analysis included as many of the following four categories as were available: fish tagged upstream of LGR and transported from LGR; fish tagged upstream of LGR and detected and returned to river at LGR; fish tagged at LGR and transported from LGR; fish tagged at LGR and released in the tailrace of LGR. Each LGO analysis included only two groups, transported and in-river, as all fish were tagged upstream of LGO. Although analyses were based on SARs for daily groups, there was too much sampling variability in the daily points for effective visual display. Instead, our figures included estimated SARs for daily groups pooled into weekly periods. Weekly points, with relatively less "noise," effectively summarized the daily data and provided a clearer picture.

- A statistical regression method (Poisson log-linear regression) was used to fit a curve or a straight line to the daily SAR data points, and to assess the fit statistically. Potential factors to explain SARs were migration group (transported or in-river migrant), tagging location, and date of passage (day of year). Two- and three-way interactions among these factors were also considered. Information-theoretic (AIC-based) methods were used to identify a best-fitting model for each species and rearing-type combination in each year. As from any regression method, the resulting lines and curves represent a "smoothing" of the data points, in this case the estimated daily SARs, and the data points themselves were "scattered" around the smoothed line.

- Details of river environment (e.g., flow, spill, water temperature, number of fish migrating through dams, etc.) were not considered explicitly in this analysis (i.e., measures of these characteristics were not included as factors potentially affecting SAR or T:M).

- Daily T:M ratios estimated from the fitted SAR curves were assessed relative to two different "standards." T:M greater than 1.0 indicated that among fish in the bypass system, those that were transported returned at a higher rate than those that were returned to the river. The second standard, designed for inference to the run at large, was based on a correction factor calculated to compensate for the bypass effect. These correction factors "raised the bar" to a standard higher than a T:M of 1.0. The estimated bypass effect varied by year and species, and the resulting alternative standards ranged from 1.02 – 1.04 for wild Chinook and 1.03 – 1.11 for wild steelhead at LGR and 1.08 – 1.22 for wild Chinook and 1.08 – 1.31 for wild steelhead at LGO. T:M greater than this alternative standard indicated that transported fish in the run at large returned at a higher rate than migrants in the run at large.

- Regression results for each species/rearing-type/year were illustrated with a set of figures: one small figure for each tagging location showing point estimates of SAR for weekly pooled groups, with standard errors, and the best-fit curves or lines from the regression for transport and migrant fish; and one large figure showing the curves for T:M through the season derived from best-fit SAR curves, along with 95% confidence "envelopes" around the curves. Appendix A includes 42 such sets of figures for transport from LGR. Appendix B includes 42 sets for transport from LGO.

- The best-fit curves for T:M ratios were summarized, relative to the 1.0 standard and the alternative standard, in a series of color-coded figures (Figures 2-5 for transport from LGR and Figures 6-9 for transport from LGO). Each horizontal line in the figures represents one migration season for a species/rearing-type/tagging location combination, with a series of color-coded boxes representing days in the migration season. The color coding indicates on which days the estimated T:M was less than the standard, which days the estimated T:M was greater than the standard, and whether the difference between estimated T:M and standard was significant.

- In most cases, estimated T:M remained constant or increased throughout the migration season. For both species and both rearing types in all migration years before 2006, the estimated T:M ratio exceeded the alternative standard (i.e., exceeded the “higher bar” and so therefore also exceeded the 1.0 standard) for fish that arrived at LGR on May 1 or later, and the difference was usually statistically significant.

- In migration years 2006-2008 there have been some exceptions to the post-May 1 pattern: estimated T:M still usually increased through the season, but there were instances when the estimate did not exceed the standards until later in May, and for hatchery Chinook in 2006 the estimated T:M was less than 1.0 throughout the season. It is difficult to determine at this point whether altered spill operations and returning all bypassed smolts to the river during the early part of the migrations in 2006-2008 have resulted in changed T:M ratios compared to earlier years. Estimated T:M ratios for some groups at LGR were apparently lower, at least early in the season (e.g., hatchery steelhead and hatchery Chinook 2006, wild Chinook 2006, and hatchery Chinook in 2008). Adult returns are incomplete for some of these migration years, and final results cannot be evaluated for another year or two.

- The analyses presented in this report are intended to assist managers with the decision of when to transport during the spring migrant period. As noted by the Independent Scientific Advisory Board (ISAB 2008-5), besides T:M ratios for spring-summer Chinook and steelhead, managers should also consider other factors, including maintaining the ability to learn how populations respond to current dam configurations under a range of operations and conditions, the effect of transport on straying rates, and the response to transport of ESUs other than spring/summer Chinook and steelhead. Additional years of adult returns from ongoing and future studies are needed to fully elucidate these issues.