FISH PASSAGE CENTER

1827 NE 44th Ave., Suite 240, Portland, OR 97213

Phone: (503) 230-4099 Fax: (503) 230-7559

http://www.fpc.org/

e-mail us at fpcstaff@fpc.org

MEMORANDUM

TO: Rob Lothrop, CRITFC

Michele DeHart

FROM: Michele DeHart, FPC

DATE: October 5, 2010

RE: Delayed/latent mortality and dam passage

In response to your request the Fish Passage Center staff reviewed available analyses and evidence regarding delayed and or latent mortality of juvenile salmonids associated with dam passage. **Our overall conclusion is that there is a broad range and scope of evidence which indicates that powerhouse passage and the transportation/collection/bypass systems at mainstem dams results in significant delayed/latent mortality of juvenile salmonids which reduces adult returns.** The conclusions listed below are followed by detailed discussion of each point.

- Several independent studies have indicated that delayed and latent mortality occurs in fish passing the powerhouse collection bypass systems.
- Two independent analyses of PIT tag data, the Comparative Survival Study and one conducted by the University of Washington, that utilized different methods both concluded that bypass passage significantly reduces adult returns.
- Bypass and transported fish have a similar experience in passing through powerhouses. Therefore the finding that significant delayed mortality occurs in bypassed and transported fish is logical considering that both groups largely follow the same route through the majority of the powerhouse collection passage system at dams.
- Acoustic tag studies at John Day and the Columbia River estuary indicate that latent mortality occurs and that individual project acoustic tag estimates of bypass survival do not capture latent mortality as a result of bypass passage.
- Radio tag estimates of survival at McNary conducted in the same years as the McNary transportation study resulted in overly optimistic estimates of survival for bypassed fish because they did not capture latent mortality. The results of the transportation study

diverged from the radio tagging results in that transported and bypassed juveniles had reduced adult returns. These transportation studies at McNary indicate that delayed/latent mortality occurs in bypass groups.

- Additional independent analyses, conducted by Pacific Northwest Laboratories, and state and federal fishery agencies over the past several years, similarly indicate that delayed and latent mortality occurs in fish passing the powerhouse collection bypass systems.

Collection/Transport/Bypass Systems

The fish passage systems at mainstem Columbia and Snake Rivers dams were designed primarily to collect fish for the Corps of Engineers fish transportation program. Regardless of whether bypassed fish are returned to the river or transported, they have largely the same powerhouse passage experience up to the point that they are either sent through a pipe to the raceways for transportation or to a pipe back to the river. In the simplest terms the collection/transportation/bypass powerhouse bypass systems separate the fish into a smaller volume of water.

Four dams on the Columbia and Snake Rivers contain transportation facilities as a part of their juvenile bypass system: McNary Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam. All of these projects except Lower Granite Dam contain a primary and secondary bypass (Lower Granite does not have a primary bypass). During transport operations all juvenile fish move through the secondary bypass which includes the transport facility, the sample facility, and a direct diversion back to the river. Therefore, during transport operations, all juvenile fish that are collected experience the same powerhouse environment to a point, the fish move up submerged screens in front of powerhouse turbines into the gatewells and through orifices into the collection channel over the debris/fish separator. At this point in passage they can be directed to the transport facility, the sampling facility, or directly back to the river.

During non-transport periods at McNary Dam, Little Goose Dam, and Lower Monumental Dam juvenile fish may be primarily bypassed. At projects operating in primary bypass mode, juvenile fish that are collected experience the same condition of moving up submerged screens in front of powerhouse turbines into the gatewells and through orifices into the collection channel but are diverted to the primary bypass before going over the debris/fish separator and are returned directly back to the river.

Juvenile fish bypass facilities at John Day Dam include submersible traveling screens (STS), vertical barrier screens (VBS), and orifices in each turbine unit gatewell. The bypass collection conduit leads to a channel which carries collected juvenile fish to the river below the dam when the smolt monitoring facility is not in operation (bypass mode).

At The Dalles Dam turbine units are not screened. Juvenile fish passage consists of the ice and trash sluiceway and orifices in each gatewell. The ice and trash sluiceway is a rectangular channel extending along the total length of the powerhouse and is located in the forebay side of the powerhouse. Gatewell orifices allow flow into the sluiceway and provide a route for passing fish from the gatewells to the sluiceway.

Juvenile fish passage routes at the Bonneville Dam (Powerhouse I) consist of an ice and trash sluiceway and minimum gap runner (MGR) turbines. Juvenile fish passage facilities at the Bonneville Dam (Powerhouse II) consist of turbine intake extensions (TIEs); submersible traveling screens (STSs); vertical bar screens (VBSs); orifices in all gatewells flowing into a fish collection channel; an excess water elimination facility; and a 48" fish transport pipe which connects the collection channel to the tailrace where a sampling facility is located.

Buchanan et al. draft September 2010

A recent study (Buchanan et al. Draft, September 2010) presented an analysis of the effects of bypass passage during the juvenile migration using a model approach and actual PIT tag data. The ROSTER model is a release-capture model that uses both juvenile and adult PIT-tag detection data to estimate reach survival, detection probabilities, and transportation effects for salmonids migrating through the FCRPS.

The authors compared the actual number of adults observed for each juvenile detection history with the number of adults expected based on ROSTER results assuming that there was no bypass effect (The model assumes that detection within the juvenile bypass system at any dam has no effect on subsequent survival). The results presented from the ROSTER model showed a consistent pattern of observing more adult returns than expected from smolts that were not detected as juveniles. In comparison, smolts bypassed as juveniles consistently showed fewer adult returns than predicted by the model. The authors concluded that there was strong evidence that the adult return rates for Chinook salmon and steelhead smolts were adversely affected by passing via bypass systems at dams as juveniles. Some dams were shown to be worse than others in terms of their effects on adult returns. For example, effects as large as 27 – 33% fewer detections than expected were demonstrated for PIT tagged Chinook that were bypassed at Little Goose Dam. Additionally, the authors reported that adult return rates tended to decline the more often a fish was bypassed during outmigration. In some cases, there also appeared to be a significant synergistic effect of multiple bypass experiences, where the effect of passing two dams was greater than the sum of the effects of the two dams separately.

Concerns about the utility of using the ROSTER model (Buchanan et al. 2010) to measure the bypass effects on SARs were raised by NOAA, at the recent bypass effects workshop in Walla Walla, WA (Sep 23rd, 2010). These included:

- The ROSTER model is complex and estimates upwards of 30 different parameters and therefore may not be able to capture delayed effects of bypass accurately.
- The ROSTER model could have assumption violations due to heterogeneity in capture probabilities for smolts at dams.
- Bypass effects expressed within the hydrosystem are inseparable from bypass effects expressed after smolts pass Bonneville.

However, it must be remembered that this analysis is only one part of the decision framework and there are other studies that have come to the same conclusion that do not have these potential biases associated with the methodology.

Comparative Survival Study draft Annual Report 2010

In Chapter 7 of the 2010 CSS draft report, bypass effects are measured using a logistic modeling analysis of PIT tagged smolts. This approach evaluated the effects of bypass history on SARs from Bonneville Dam outmigration as a juvenile until Bonneville Dam return as an adult. This approach utilized data from PIT tagged smolts that survived to and were detected at Bonneville Dam and thus avoids all of the concerns raised regarding the use of the ROSTER model.

This analysis showed a statistically significant reduction in post-BON SARs per bypass experience at upriver dams for both Chinook and for steelhead. For Chinook, estimates of bypass effects were similar across Snake and Columbia River dams whereas for steelhead, estimates of bypass effects were much more severe at MCN and JDA dams than they were at Lower Granite, Little Goose or Lower Monumental dams.

Chapter 7 of the 2010 CSS draft report also presents a multi-year meta-analysis comparing SARs of smolts that were bypassed at the collection dams (LGR, LGS and LMN) to those smolts that pass undetected through the collection dams. Those analyses showed that SARs for wild Chinook that pass undetected through the collection dams averaged 52% higher than SARs for wild Chinook that were bypassed. Similarly, SARs for wild steelhead that pass undetected through the collection dams averaged 91% higher than SARs for wild steelhead that were bypassed.

The results of the Chapter 7 CSS analyses lend support to the Budy et al. (2002) hypothesis that the cumulative effects of migration conditions through the hydrosystem affect levels of delayed mortality expressed in post-BON SARs of both Chinook and steelhead and corroborates the work of Schaller and Petrosky (2007). The CSS draft report results also provide evidence that bypass experiences influence SARs, with smolts that pass undetected through the dams demonstrating higher SARs than those smolts that are bypassed one or more times.

Petrosky and Schaller, 2010

In an independent and separate analysis of the influence of river conditions and ocean conditions on survival rates of steelhead and Chinook salmon, Petrosky and Schaller (2009) utilized a long time series of smolt to adult return rates in multiple regression models. They found that survival rates during the smolt to adult and first year ocean life stages for both species were associated with both ocean and river conditions. Best fit, simplest models indicate that lower survival rates for Chinook salmon are associated with warmer ocean conditions, reduced upwelling in the spring and with slower river velocity during the smolt migration or multiple passages through powerhouses at dams.

Schaller and Petrosky 2007

The authors found that Snake River yearling spring/summer Chinook salmon populations exhibited survival patterns similar to those of their downriver counterparts, but survived only one-fourth to one-third as well. The hypothesis that delayed mortality decreased and became negligible with more favorable oceanic conditions appeared inconsistent with the patterns observed for the common year effect and estimates of delayed mortality of in-river migrants. The authors state, “A plausible explanation for this persistent pattern of delayed mortality for Snake River populations is that it is related to the construction and operation of the hydrosystem.”

Scheuerell & Zabel 2006, NOAA

During the Biological Opinion remand process, the issue of latent delayed mortality, and its effects on post-Bonneville SARs were examined by technical committees in the collaborative process. NOAA staff distributed a technical analysis (Scheuerell and Zabel 2006) evaluating the effects on migration timing and the number of bypass experiences on post-Bonneville SARs. Those analyses found that the number of bypass passages experienced upriver by smolts was significantly associated with reductions in post-Bonneville SARs.

Marsh et al 2009, NOAA / Ham et al. 2009, PNNL

Evidence of delayed mortality associated with bypass passage at McNary Dam was provided in the final report of the analyses of transportation at McNary Dam In a recent report, NOAA provided estimates of bypass/in-river, bypass/transport, and in-river/transport SAR ratios for yearling Chinook from McNary Dam (Marsh et al., 2009) for 2002 through 2004. Marsh et al. (2009) provided estimates of bypass/inriver SAR ratios of 1.02 (2002), 0.62 (2003), and 0.52 (2004) for yearling Chinook. These results suggest that yearling Chinook that were bypassed at McNary Dam (and returned to the river) have lower SARs than those that passed undetected (i.e., in-river). It is worth noting that estimates of SARs for “in-river” fish from this analysis include fish that passed through turbines as well as through the spill way. It is likely that the bypass/inriver SAR ratio would have been even lower (suggesting an even greater bypass effect) if spillway passed fish could be separated from turbine passed fish.

Radio telemetry studies with yearling Chinook at McNary Dam during these same years (2002-2004) estimated bypass/spillway survival ratios of 0.95, 0.93, and 0.93 (Table 6.1 from Ham et al., 2009). These telemetry results suggest very little bypass effect. However, PIT-tag analyses from the McNary transportation study (Marsh et al., 2009) indicate an effect of the bypass on yearling Chinook adult returns, when compared to those fish passing undetected. This disagreement in results illustrates that there is likely delayed mortality associated with the bypass system at McNary Dam and that short reach survival estimates, such as those generated with telemetry studies, do not capture the full effects of bypass systems on juvenile salmon.

McMichael et al. 2010, PNNL

A similar pattern with delayed mortality associated with bypass passage can be seen in recent acoustic telemetry studies conducted at John Day Dam, particularly for steelhead. A 2009 study using acoustic telemetry data indicated that, among all passage routes, passage through the juvenile bypass system resulted in the highest survival estimates for yearling Chinook (0.975), steelhead (0.966), and subyearling Chinook (0.908) (Weiland et al., 2010). However, another study conducted in the same year, which used the same acoustic tagged fish, indicated that steelhead passing through the juvenile bypass system at John Day Dam had the lowest survival to the estuary (0.42-0.59, depending on the passage route at Bonneville Dam) (McMichael et al., 2010). Steelhead juveniles that passed John Day Dam through deep spill had estuary survival that ranged from 0.55 to 0.70 (depending on the passage route at Bonneville Dam). Passage through the TSW's at John Day Dam resulted in estuary survivals that ranged from 0.56 to 0.65 (depending on the passage route at Bonneville Dam). Estuary survival was not estimable for steelhead juveniles that passed through the John Day turbines (McMichael et al., 2010).

Ferguson et al, 2006, NOAA

Another study that found evidence for delayed mortality associated with powerhouse passage was Ferguson et al (2006). This analysis showed that fish passing through turbines have a lower survival rate when survival was measured over a longer reach than when measured over a short reach. Fish released into turbines had relatively high survival to the tailrace of McNary Dam (0.93 to 0.946) as measured by balloon tags. Survival to arrays located 45 km downstream was between 0.814 and 0.858 and was found to be significantly lower (alpha of 0.05) Ferguson et al (2006) concluded that direct mortality (mortality to the tailrace of the dam) made up 30% to 54% of total mortality. In this case delayed mortality was up to 70% of total mortality estimated in this study.

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DATA REQUEST FORM

Request Taken By: Michele **Date:** Sept 20, 2010

Data Requested By:
Name: Rob Lothrop **Phone:**
Address: CRITFC **Fax:**
Email:

Data Requested:
Review information regarding delayed mortality associated with Powerhouse passage. Attend delayed mortality workshop - (COE) on Sept 23, 2010.

Data Format: Hardcopy ☐ Text ☐ Excel ☐

Delivery: Mail ☐ Email ☐ Fax ☐ Phone ☐

Comments:

Data Compiled By: FPC staff **Date:** Oct. 5, 2010

Request # 60

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