COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
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Memorandum

To: Adaptive Management Team (total dissolved gas)
From: Bob Heinith
Date: July 3, 2008
RE: **Review of Adult Passage Through Different Dam Passage Routes**

Overview

The adult life history of salmon and steelhead is critical to overall population performance. The fecundity of adult females represents the potential for production of the next generation (Groot and Margolis 1991). Given the significant and continuing declines in Columbia River steelhead and salmon (McClure et al. 2003; ICTRT 2007), additional focus needs to be placed on increasing survival of returning adults. Multiple dam passage through the hydrosystem adds a significant environmental stressor for anadromous fish that must have suitable corridors in addition to other suitable habitats necessary for growth and reproduction (Caudill et al. 2007). Such stressors affect populations directly with respect to direct and delayed losses and also can reduce population genetic fitness over time (Caudill et al. 2007). Small increases in adult escapement and survival to spawning areas have the direct potential to increase productivity for wild stocks (Keefer et al. 2005).

Adult steelhead and salmon often migrate downstream through or over hydroelectric dams. This behavior has been related to "overshooting" natal tributary spawning areas (Boggs et al. 2004a) or in the case of steelhead kelts returning to sea and then returning to the river to repeat spawning, it is an essential life history action referred to as iteroparity (Wertheimer and Evans 2005). From radio telemetry data based upon escapement data from tributaries or hatcheries, many of these fish do not survive to spawn (Table 1). Recent radio telemetry studies funded by the Corps indicate a minimum estimate of winter mortality for fallback steelhead at 14.5%, based upon unknown loss in the Federal Columbia River Power System (FCRPS) and would have been higher if the last live record was used rather than the January 1 criteria for FCRPS steelhead overwintering (Keefer et al. 2007).

Table 1. Percent of adults that migrated downstream over dams and returned to downstream natal spawning sites (data from Boggs et al. 2004a).

Dams	Fall Chinook	Spring/Summer Chinook	Steelhead
The Dalles, John Day, McNary	45%	18-30%	6-26%
Ice Harbor	79%	NA	NA

Reduced adult survival is likely the result of physical trauma, injury, energetic expenditures or poor environmental conditions. In general, adults that migrated downstream (i.e. fallback after upstream migration) over a dam escaped to natal tributaries or hatcheries at lower rates than adults that did not exhibit this behavior (Boggs et al. 2004a; Boggs et al 2004b; Keefer et al. 2005; Caudill et al. 2007). Following harvest, the greatest attributable loss of adults is linked to adult fallback or downstream migration over dams (Keefer et al. 2004). Thus, the downstream route of adult passage is an important factor that contributes to survival and ultimate escapement to spawning areas and spawning success, reproductive fitness and genetic integrity.

Downstream Routes of Passage

In general, there are four downstream passage routes available to adults. These include turbines, spillway, surface bypass and screen bypass systems. While some adults may pass downstream through dam navigation locks, based upon radio-telemetry data this is not believed to be a significant passage route.

Screen bypass systems. Installed at all Corps dams except The Dalles, screened bypass systems were developed in the 1990's to divert juvenile salmon from turbine intakes and to allow for transportation of juvenile salmon. They were not designed for adult passage. For example, orifice entrances from gatewells into collection channels are large enough for juveniles but were not designed for adult passage and can cause injury to adults that must pass through them. Further, evidence from tagging studies and review of smolt-to-adult survival rates indicate that screen systems are not likely a good passage route even for juveniles. For example, Budy et al. (2002) and Schaller et al. (2007) found that juveniles that passed through screen systems at dams had lower survival rates than those salmon that passed through a combination of turbine and spill passage. Juvenile and adult salmon that are subjected to screen system passage are exposed to and held at temperatures that are significantly warmer than that found in the ambient river (WDFW Weekly Dam Monitoring Reports 1999-2007). Temperatures in bypass systems have been found to exceed water quality standards for much of the summer salmon migration (WDFW and ODFW 1999-2007).

In probably the most comprehensive study of adult passage downstream through screen bypass systems, Wagner and Hilson (1993) found that adult steelhead injury rates were in the range of 40-50%. Less than 1/3 of the adults that passed through the screen system and turbines reascended the McNary fish ladder (Wagner and Hilson 1993). Wagner (1991) noted that the

peak downstream migration period for steelhead was November 29 and estimated that over 7,000 adult steelhead migrated downstream over McNary Dam during just the month of November.

Many adult steelhead kelts migrate downstream through the hydrosystem in April and May. Radio telemetry studies indicate that between 10-50% of steelhead in the Columbia Basin are repeat spawners and return to the ocean (English et al. 2001; Evans and Beaty 2000). Wertheimer et al. (2003) estimated that 70.9% and 66.8% of the adult steelhead population passing over McNary and John Day dams respectively were kelts. Wertheimer and Evans (2005) noted that during non-spill periods, only 47.5% of steelhead kelts were diverted from turbine passage through the dam screen bypass systems. Adult steelhead during non-spill periods, such as fall and winter, suffer significant impacts from downstream passage. During the non-spill periods, about half of radio tagged steelhead that at least partially overwintered in the FCRPS and were classified as "…..unsuccessful in returning to upstream areas"as dam fallbacks during the winter period (Keefer et al. 2007). Keefer et al. (2005) noted that in general, fall Chinook and steelhead have a more negative response to downstream migration over dams because much of the run timing of these stocks occurs during reduced or non-spill periods.

Spill. In general, the available information provides evidence that spill and surface bypass are the most benign downstream passage routes for adults. Keefer et al. (2005) noted that when spill is available, it is the most utilized route of passage. Table 2 illustrates some of these differences. During these periods, in general, adults are more successful in escapement to tributaries and hatcheries after downstream dam passage. As with migrating juvenile salmonids, spill has also been demonstrated reduce travel and passage times through projects and pools in the lower Columbia River (Wertheimer and Evans 2005).

Table 2. Steelhead kelt fish passage efficiencies through Lower Columbia dams with and without spill (data from Corps 2008).

Dam	% Spill	% Fish passage efficiency
Bonneville	37	84
Bonneville	0	68
The Dalles	30	99

Turbines. Adult salmon direct mortality through turbines has been estimated from 22%-51% (Wagner and Ingram 1973; Buchanan and Moring 1986; Liscom and Sturehrenberg 1985). High rates of turbine mortality are likely associated with the positive relationship between fish size and increased probability of turbine blade strike (Coutant and Whitney 2000). While specific adult indirect mortality studies could not be found for this review, juvenile salmon indirect mortality studies provide an indication of delayed impacts to adults. These impacts from turbine passage may be substantial. For example, Kostecki et al. (1987) found that 75% of Atlantic salmon smolts that had passed through turbines had suffered microscopic brain and muscle lesions. These injuries compromised their later survival. Ferguson et al. (2006) found that delayed mortality for yearling Chinook that passed through the McNary turbines comprised 46-

70% of the total mortality, based upon juvenile salmon detections 15 km below the dam. Wertheimer and Evans (2005) noted that the poor migration success rates for kelts through the lower Snake River without spill in 2001 was likely a combination of mortality from turbine passage and energetic expenditures from migrating through low velocity reservoirs. When spill was provided in 2002, passage efficiencies increased substantially.

Surface bypass. Studies of fish passage efficiency for steelhead kelts at the Bonneville Second Powerhouse Corner Collector indicate that surface bypass structures are an emerging, promising adult downstream passage route to be further developed. The surface orientation of adults and the surface orientation of these structures are likely the reason for success. For example, Wertheimer (2007) found that 80% of kelts entering the Bonneville Second Powerhouse forebay passed downstream through the Corner Collector. Surface bypass structures such as sluiceways at other dams appear to provide similar passage efficiencies. As mentioned before, telemetry studies indicate that providing surface bypass opportunities can reduce dam passage delays. However, development and placement of such structures is site specific and perhaps species specific (Wertheimer 2007). The combination of spill adjacent to surface bypass structures provides velocity and flow cues for adults to help guide them to surface bypass structures and may prove to be the best future downstream passage route.

Conclusion

The studies reviewed indicate that spill and surface bypass and probably a combination of both provide the safest downstream passage route for adult migrants, whether they are fallbacks or steelhead kelts heading seaward. Direct and delayed mortality rates and passage delays and reduced by these routes, with resulting increases in escapement. Eliminating the 115% TGP forebay monitor requirement will likely increase spill levels and will result in increasing fish passage efficiencies and adult survival and escapement to tributary and hatcheries. High levels of uncontrolled and/or overgeneration spill during high flow years has been shown to increase adult fallback rates for spring migrants and delay their migration (Boggs et al. 2004a; Keefer et al. 2005). However, the existing evidence indicates that adult downstream passage through and over dams is most successful under managed, controlled fish spill levels.

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