Appendix C
Wenatchee Subbasin Plan

EFFECTS OF HYDROELECTRIC DAMS
ON VIABILITY OF WILD FISH
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The existence and operation of the Columbia River Hydrosystem poses risks to wild populations of anadromous salmonids. Run-of river dams present passage obstacles to both adult and juvenile migrants, and the water management of storage reservoirs for hydropower production has reshaped the seasonal hydrograph. Both of these elements have had deleterious effects on salmon resources in the basin. This section focuses on Upper Columbia River populations, but in some cases refers to data from the Snake River or lower Columbia to illustrate basic principles.

Effects on Juvenile Life Stages

Migrating smolts of all species traverse the impounded mainstem Columbia during their seaward journey, most notably the two ESUs of Upper Columbia spring chinook and summer steelhead. Also, egg-through-smolt life stages of ocean-type summer/fall chinook incubate, rear, and migrate through the upper and lower Columbia River segments. During downstream migration, smolts encounter two general classes of effects, those associated with passage at the dams and those experienced within the reservoirs.

Smolt travel time and survival through a series of projects (dam and pool) are two key indices used to assess the effects of the hydrosystem on the performance of salmon populations. Typically PIT-tagged hatchery fish or a mixture of hatchery and wild fish are used as indicator stocks. In the Snake River, known wild fish are used on a regular basis, but in the Upper Columbia there has been no concerted effort to tag known wild fish. Therefore, in the Upper Columbia, managers must rely on hatchery and mixed populations to generate performance indices. However, the hatchery and mixed populations have generally proved to be adequate surrogates for representing the migratory characteristics of wild populations within the impounded Columbia-Snake River system (FCRPS BiOp 2000). Herein, this section relies on the same complex of populations for representing wild stocks from the Upper Columbia.

Salmon Migration and Survival

As noted elsewhere in this plan, both Mullan et al. (1992) and Chapman et al. (1994, 1995) identified the construction and operation of the Columbia River hydrosystem as a primary agent contributing to the decline of spring chinook and steelhead populations in the upper Columbia. Chapman et al. (1994, 1995) arrived at the same conclusion for sockeye and summer/fall chinook as well. These discussions focus on spring chinook and steelhead, but in most cases will apply to sockeye as well. Ocean-type summer/fall

chinook populations that migrate during the summer face unique conditions. We do not discuss details for ocean-type chinook at his time.

Smolts

Dam Passage Effects

Smolts passing each dam incur effects that result in elevated mortality. Survival rates differ among passage routes and dams. In the Snake River, spillways provide the safest routes, followed by bypasses, with turbines being the most injurious (Muir et al. 2001). In a meta-analysis of smolt survival data, Bickford and Skalski (2000) affirmed that spillways generally provide a safer route of passage than do Kaplan turbines. Their study included dams in the Columbia and Snake rivers.

Smolt passage survival though one or more projects (reservoir and dam) provides a more complete index of total hydropower impacts, since it reflects mortality incurred passing the dam and that within the reservoir. Predation on smolts by fish and birds is the primary agent causing mortality in the impoundments. During the 1980s, system survival studies were conducted through the Upper Columbia from Pateros to Priest Rapids tailrace. The mean per-project survival ranged from 84 to 87.5% for steelhead (FPC 1985, 1986; McConnaha and Basham 1985). For spring chinook, McKenzie et al. (1983 and 1984) reported mean per-project survival estimates that ranged from 83.4 to 88.7%.

Today, passage survival at certain dams appears to have improved with the implementation of contemporary configurations and operations. For example, recent project survival estimates from Rocky Reach and Rock Island dams indicate that smolt survival is improved over historical conditions. Skalski et al. (2003) summarized data for Rock Island Dam and Skalski et al. (2001) did so for Rocky Reach Dam . They considered all project survival estimates obtained since 1998, using all tag types (radio, PIT, and acoustic).

Species/life stage	Rocky Reach	Rock Island
Yearling Chinook	90.3% (4.0)	93.2% (0.6)
Steelhead	96.4% (0.3)	94.6% (0.9)

Estimates for Rocky Reach are limited, particularly for yearling chinook where PIT and radio estimates were averaged for one year, 1998. Prototype surface collectors of various configurations and operations were in place at Rocky Reach during all years. Thus current survival may differ since the production-scale surface collector has been completed and in full operations. Future evaluations will provide an evaluation of the effects on project survival.

Also, the predator-control program directed at removing adult northern pikeminnow has been in place since the mid-1990s. This has no doubt contributed to increasing survival through reservoirs, which would be reflected in project survival estimates. Although quantifying the effectiveness of that program alone, in terms of improved smolt survival, has been technically difficult to accomplish.

Migration Rate Effects

The emplacement of nine dams on the mainstem Columbia has slowed river velocities considerably. This has resulted in slower migration rates through the impounded system. To illustrate this, Ebel and Raymond (1976) and Bentley and Raymond (1976), for example, estimated that after dam emplacement, travel times of yearling chinook salmon and steelhead increased at least two-fold over pre-impoundment conditions. Slower migration seaward can affect smolt survival inriver and perhaps at seawater entry. Inriver, smolts have increased exposure time to predatory species and changing water conditions. Both of these can result in higher mortality than realized under pre-impoundment conditions. A protracted migration may result in suboptimal development and compromise seawater adaptation and survival, although this remains to be definitively demonstrated. Clearly, evidence for steelhead indicates that exposure to warming inriver temperatures depresses the smoltification process and promotes recidivism when temperatures exceed 12-13˚C.

Slower migration may also result in other types of delayed effects that could be manifested in the form of poor marine survival. Congleton et al. (2002) monitored the physiological condition of stream type spring/summer chinook salmon migrating from Lower Granite Dam to Bonneville Dam during 1998-2002. They found that body lipid and protein masses decreased significantly and with increased travel time. Slower migration forces juveniles to use caloric reserves beyond levels expected to occur under a free-flowing river, yielding swift migration speed. Such a tax on body reserves could compromise smolt survival, particularly during early seawater residence.

The flow augmentation program adopted by the fisheries agencies and Tribes is meant to offset deleterious effects associated with impoundment. However, recently the ISAB (2003) has questioned the effectiveness of that program.

Adults

Chief Joseph Dam lacks an adult fishway and has permanently blocked passage to spawning and rearing areas upstream from that site since 1961, when the dam was completed. All other dams from Wells to Bonneville are equipped with adult fishways that permit upstream passage. Although these dams are obstacles, they do provide effective fish passage ways in most cases. Some fishways have been found to be problematic because their specific location or configuration exacerbates fallback. The Bradford Island Fishway at Bonneville Dam is a good example of such a problem site.

Survival Estimates

Accurate estimates of adult passage survival do not exist, because thus far they have proved impractical to obtain. Typically, survival indices are reported, which are best characterized as minimum survival estimates. Most survival indices have been obtained using radio-telemetry methods. Fish are tagged at the foot of the reach and monitored as they pass dams to some terminal sampling location. Survival through the reach of interest is a minimum survival estimate because certain fish fates have not been accurately accounted for in many studies. These include tag failure, tag regurgitation, tributary turnoff (some cases), all harvest removals, and for some species cessation of migration associated with mainstem spawning. Thus the survival index based on tagged fish arriving at the uppermost dam represents an estimate of minimum survival through the reach. Recently the installation of an adult PIT detection system at Wells Dam has provided the opportunity to generate estimates similar to those obtained using radio telemetry.

Adult survival through portions of the Upper Columbia has been estimated in some years over the last decade. In general, survival rates of both steelhead and spring chinook are high. This has been demonstrated using a number of approaches.

Steelhead—English et al. (2001, 2003) estimated that a minimum of 93.3% and 94.2% of the steelhead arriving at Rocky Reach Dam survived to known spawning areas, or remained upstream from the dam. These estimates are consistent with estimates from the Snake River and lower Columbia, which generally average near 96.8% per project (Rocky Reach BiOp 2003). Also, as reported in that BiOp, PIT tag-based survival estimates from McNary to Wells Dam averaged 97% per project.

Yearling Chinook—In 2002, PIT tag-based estimates indicate that the minimum survival of spring chinook ranged from 95.8% to 100% for two stocks tracked from McNary to Wells Dam. That range is consistent with values reported for Federal Columbia River Power System projects, which average a loss near 2.4% for spring chinook (Rocky Reach BiOp 2003).

Overall, these collective estimates comport with estimates obtained for adults migrating through some free-flowing rivers. In fact, NOAA Fisheries concluded, "[f]urthermore, based on the observed ranges of mortality estimates for un-impounded river systems, which often exceed that observed in impounded reaches of the Columbia River, NOAA Fisheries concludes that there is a high likelihood that mortality as a result of direct, indirect, or delayed effects of passing the Project does not exceed 2% for any Permit Species" (Rocky Reach BiOp 2003, p.6-9).

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