Northwest Salmon & Steelhead Recovery Planning & Implementation

Listed Species:

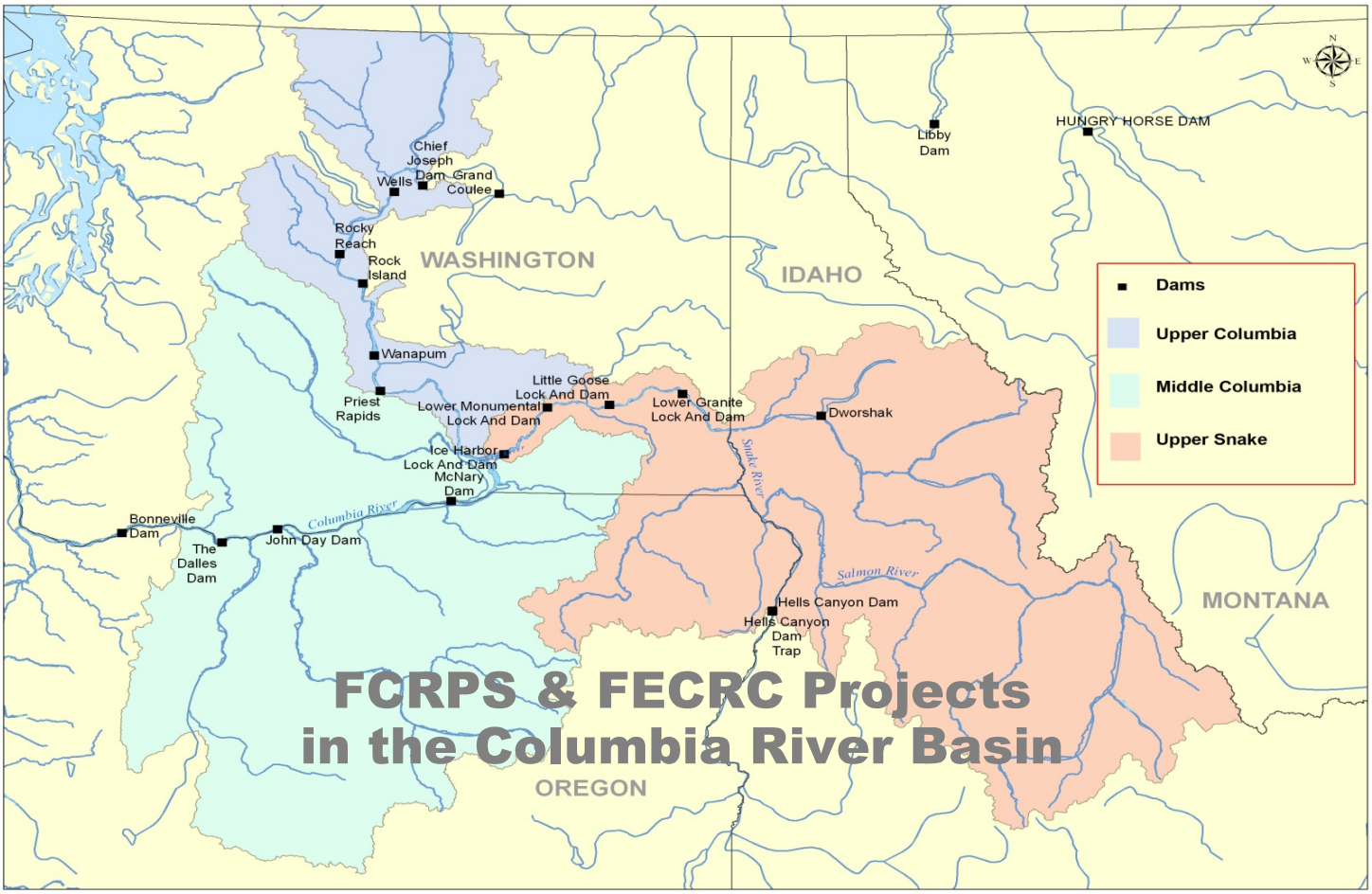
- Snake River Fall Chinook
- Snake River Spring/Summer Chinook
- Snake River Sockeye
- Snake River Steelhead
- Upper Columbia Spring Chinook
- Upper Columbia Steelhead
- Middle Columbia River Steelhead
- Columbia River Chum
- Lower Columbia River Chinook
- Lower Columbia River Coho
- Lower Columbia River Steelhead
- Upper Willamette River Chinook
- Upper Willamette River Steelhead

Hydropower Module Summary

This module summarizes the general effects of the Columbia River mainstem hydropower projects on all 13 Endangered Species Act (ESA)-listed anadromous salmonids in the Columbia basin. It addresses both the effects of the projects and the limiting factors and threats affecting listed species, as well as the actions, or strategy options, intended to mitigate for any adverse effects. The foundation for this module is the 2008 Federal Columbia River System (FCRPS) Biological Opinion, Federal Energy Regulatory Commission (FERC) licensing proceedings, and Habitat Conservation Plans (HCPs), all of which have undergone public processes. This module synthesizes these various documents and proceedings for recovery planning purposes and it supports plans for the Snake River, Upper Columbia, Middle Columbia, Lower Columbia, and Upper Willamette River species. The geographic scope includes the accessible mainstem habitat in the upper Columbia and Snake rivers, downstream to the tailrace of Bonneville Dam.

All 13 ESA-listed salmon and steelhead species in the Columbia basin use the mainstem Columbia River (and Snake River for Snake River species) for migration to and from freshwater natal areas to the Pacific Ocean. The mainstem plays a vital role in the life cycle of salmonids, whether it be for growth and maturation or returning to their natal streams to spawn. With the construction and operation of the mainstem hydroelectric projects, ecological shifts began to affect salmon and steelhead at various life stages. Mainstem dams have extirpated anadromous fish from their pre-development spawning and rearing habitats. Dams and reservoirs, within the currently accessible migratory corridor, have altered the river environment and have affected fish passage and survival. The operation of water storage projects has altered the natural hydrograph of the Snake and Columbia rivers. Water impoundment and dam operations also affect downstream water quality characteristics, including water temperatures, which are vital to the survival of anadromous species.

Current hydropower programs and operations, and the subsequent mitigation actions, are intended to avoid jeopardy and contribute to recovery. There is no distinction between hydropower actions intended to meet ESA regulatory requirements and those intended purely for recovery. The material that follows synthesizes the effects of current mainstem hydropower projects on habitat conditions, recovery strategies, and actions intended to mitigate for any detrimental effects resulting from the hydropower programs, and describes salmonid survival rates for both federal and non-federal hydropower projects.



Habitat Limiting Factors & Threats

The construction of hydroelectric and water storage projects in the 20th century blocked access to important historical production areas for salmon and steelhead. The construction of these and additional run-of-river projects inundated mainstem habitat, altered water quality (reduced spring turbidity levels) and quantity (seasonal changes in flows and consumptive losses resulting from use of stored water for agricultural, industrial, or municipal purposes), influenced natural regulation of water temperature (including generally warmer minimum winter temperatures and cooler maximum summer temperatures), altered water velocity (reduced spring flows and increased cross-sectional areas of the river channel), changed food webs (including the type and availability of prey species), and affected safe passage (Williams et al. 2005; Ferguson et al. 2005).

Migration Corridor

Within the mainstem Snake and Columbia river migration corridors, both dams and their associated reservoirs influence the current status of Columbia basin salmon and steelhead. To a greater or lesser extent specific to each dam, the dams present fish passage hazards, causing passage delays, and varying rates of injury and mortality.

Adult Passage

There is currently no indication that reservoirs substantially delay adult migration upstream (Ferguson et al. 2005). While the upstream migration of adults can be slowed as fish search for fishway entrances and navigate through the fishways themselves, they migrate more quickly through the relatively slow reservoirs. Fish ladders, which allow upstream passage of adults, are provided at the eight mainstem projects in the lower Snake and lower Columbia rivers and the five mainstem FERC-licensed dams in the middle reach of the Columbia. Adult fish passage facilities are highly effective, but fish may have difficulty finding ladder entrances (delay), and fish also may be injured or killed falling back through a dam (via spillway, turbine, or juvenile bypass system). There is minimal data on the survival of adults through juvenile bypass systems. However, it seems logical to assume that survival rates would be much higher through these systems than through turbine units.

Steelhead Kelts

Not all adult steelhead die after spawning. Rather, a large fraction of adult steelhead attempt to migrate back to the Pacific Ocean. These steelhead, termed kelts, attempt to migrate back down stream to the ocean. However, very few post-spawn adult steelhead survive downstream passage through the hydrosystem and so do not return to spawn again. FCRPS passage survival

ranged from 4.1 to 6.0% in the low flow year of 2001 to 15.6% in 2002 and 34% in 2003 (Boggs and Peery 2004; Wertheimer and Evans 2005). In addition to injury and mortality, kelt downstream migrations are delayed by the mainstem projects (Wertheimer and Evans 2005).

Predation

At Bonneville Dam, marine mammals (both the more common California sea lion and ESA-listed Stellar sea lion) are increasingly using the Bonneville Dam tailrace as a foraging area, presumably because the adult Chinook, steelhead, and lamprey upon which they feed are concentrated and delayed in this area as they use entrances to the dam's adult fishways.

Juvenile Passage

Historically, it is not known how long it took juvenile salmonids to traverse the free-flowing river. Today, median travel times for yearling Chinook from Lower Granite Dam to Bonneville Dam range from 14 days to 31 days depending on flow conditions. This increased travel time, termed migration delay, presents an array of potential survival hazards to migrating juveniles. Migration delay can increase their exposure to potential mortality vectors in the reservoirs, disrupt arrival timing in the estuary, and deplete energy reserves.

Dam Passage

Juvenile salmon and steelhead can be killed while migrating through dams, both directly through collisions with structures and abrupt pressure changes during passage through turbines and spillways, and indirectly, through non-fatal injury and disorientation, which leave fish more susceptible to predation and disease (direct and delayed mortality). Juveniles passing through turbine units experience the highest direct mortalities, generally in the range of 8 to 19%. Juveniles passing through spillways, sluiceways and other surface routes generally experience the lowest direct mortality rates, 2% or less. Additionally, juvenile mortalities (up to 3 to 5%) can occur in project forebays due to avian and piscivorous predators taking advantage of juveniles delaying in project forebays. Tailrace egress conditions may also pose a problem to migrating juveniles, as salmonids passing through the dam can become disoriented or injured under a turbulent tailrace environment. Such conditions can make juveniles vulnerable to predators in the tailrace.

Predation

Alterations to habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators, including northern pikeminnow, non-native walleye, channel catfish, and smallmouth bass. Dams also provide enhanced conditions for avian predators, like Caspian terns and double-crested cormorants, to effectively forage in the forebays and tailraces of the mainstem projects.

Transportation Program

Early research led to the conclusion that in most cases, the average adult return rates of predominately stream-type salmonids (spring/summer Chinook and steelhead) that are transported as juveniles exceed the return rates of fish that migrate in-river. As a result, the U.S. Army Corps of Engineers spearheaded a large-scale juvenile transportation management program in 1975 (Ebel 1980; Ebel et al. 1973; Mighetto and Ebel 1994). Currently, fish collection and transportation systems are operated seasonally at Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam (and at McNary Dam for summer migrating fall Chinook). Fish that are transported are almost exclusively barged to release points downstream of Bonneville Dam. Approximately 60 to 90% of spring migrating smolts (spring/summer Chinook and steelhead) in the Snake River basin have been transported annually (Williams et al. 2005). Recent data show that the effectiveness of transportation, in terms of the ratio of returning adults to transported juveniles (termed smolt-to adult return ratio or SAR) from the Snake River, varies among species, season, and collection location (Williams et al. 2005; Scheuerell and Zabel 2007). In general, the SARs of both transported and in-river migrating Snake River spring Chinook and steelhead tend to decrease after early May (day of arrival below Bonneville Dam). For steelhead, SARs of transported fish are typically equal to or higher than those of the surviving in-river migrants arriving downstream of Bonneville Dam. For spring Chinook, SARs of surviving in-river migrating fish are often substantially higher in early to mid May than those of transported migrants arriving downstream of Bonneville Dam. However, in late May and June, the differences are generally diminished such that SARs are nearly equal.

Mainstem Hydrologic Conditions

Flow regulation, water withdrawal, and climate change have reduced the Columbia River's average flow and altered its seasonality among other things. Flow affects juvenile travel time and the distribution of individuals among the various routes of dam passage. In general, the lower the flow through the FCRPS reservoirs, the longer the travel time for juveniles that migrate in-river.

Mainstem Water Quality

Water quality characteristics of the mainstem Snake and Columbia rivers are affected by an array of land and water use developments. Water quality characteristics of particular concern include water temperature, turbidity, total dissolved gas, and chemical pollutants. Changes in water temperature, for instance, can have significant implications for anadromous fish survival by stressing individuals, increasing the risk of disease and mortality, impacting toxicological responses to pollutants, etc. Turbidity also has a significant impact. Reduced turbidity can increase the success of predators by improving prey detection, thereby increasing smolt susceptibility to predators. Total dissolve gas, on the other hand, is the direct result of spill at dams. Spill can cause downstream waters to become supersaturated with dissolved atmospheric gases and, at high

levels, can cause a condition in fish known as gas bubble trauma, resulting in injury or mortality of both adult and juvenile salmonids. Finally, pollutants in in-flows from upstream areas are emerging as factors which can have serious negative impacts on salmonids. Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute to municipal and industrial water to the rivers. Current environmental conditions in the Columbia River estuary indicate the presence of contaminants in the food chain of juvenile salmonids including DDT, PCBs, and polyaromatic hydrocarbons (NMFS 2001). These pollutants can cause (in juveniles) immunosuppression, reduced disease resistance, and reduced growth rates during estuarine residence.

Recovery Strategies & Actions

Federal Columbia River Power System

The plan for operation of the FCRPS through 2018 is described in the U.S. Army Corps of Engineers' 2007 Comprehensive Analysis and Biological Assessment, as well as in NMFS' 2008 Supplemental Comprehensive Analysis and Biological Opinion. The information that follows is a general summary of the strategies, performance standards, metrics, and targets required to maintain or improve salmon and steelhead survival in the mainstem migration and rearing corridor for the next ten years.

Hydrosystem Metrics	
Adult Passage Performance Standards	The Action Agencies (Bonneville Power Administration, U.S. Army Corps of Engineers, and the U.S. Bureau of Reclamation) will track and confirm that the high levels of adult survival currently observed are maintained or increased through 2018. These survival rates currently range from 81.2 to 91% for Snake River spring/summer Chinook to 84.5 to 90.1% for Upper Columbia River spring Chinook. These rates are based on known-origin PIT tagged juveniles and account for known harvest and straying.
Juvenile Dam Passage Performance Standards	The Action Agencies will achieve an average juvenile Dam Passage Performance Standard of 96% survival across Snake River and lower Columbia River dams for spring Chinook and steelhead and an average of 93% survival across Snake and lower Columbia river dams for Snake River sub-yearling fall Chinook.
Achieve Juvenile In-river Survival Performance Metrics	The Action Agencies will measure annually the survival of in-river migrating fish and compare these numbers with COMPASS model estimates, which will be based on the conditions actually experienced and the expected benefits of completed hydrosystem actions, to ensure that survival improvements are occurring as expected.
Juvenile System Survival Performance Targets	The Action Agencies will achieve the expected increase in juvenile fish survival through the hydrosystem that are associated with the proposed hydrosystem actions.

Actions to Achieve Metrics

To achieve these metrics the Action Agencies will:	
	▪ Continue collaboration with States and Tribes in the implementation of actions, progress reporting, and adaptive management using fora such as the Regional Implementation Oversight Group. ▪ Operate the FCRPS to provide flows and water quality to improve juvenile and adult fish survival. ▪ Modify the Columbia and Snake river dams to increase juvenile and adult fish survival ▪ Implement spill and juvenile transportation improvements at Snake and Columbia river dams. ▪ Operate and maintain facilities at Corps mainstem projects to maintain biological performance. ▪ Implement piscivorous predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia rivers. ▪ Implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia rivers. ▪ Implement marine mammal control measures to increase survival of adult salmonids at Bonneville Dam. ▪ Provide information needed to support planning and adaptive management and demonstrate accountability related to the implementation of FCRPS ESA hydropower actions for all species (i.e., implement research, monitoring, and evaluation programs for hydropower actions and predator control actions). For specific actions, please see the 2008 FCRPS Reasonable and Prudent Alternative Action Table.

U.S. Bureau of Reclamation Upper Snake Basin Projects

Site-specific actions in the upper Snake basin are intended to provide flow augmentation to address the needs for survival and recovery of all 13 listed salmonid species. Although the physical project operations take place upstream of the migration barrier at Hells Canyon Complex, water released from the upper Snake River project reaches the lower Snake and Columbia rivers where it benefits juvenile salmon and steelhead. Flow augmentation will occur by acquiring water through rental pools and leasing or acquiring natural flow rights. The Nez Perce Water Rights Settlement and the Idaho law that implemented the settlement provide that up to 487,000 acre-feet may be provided for flow augmentation.

Federal Energy Regulatory Commission Projects

The Federal Energy Regulatory Commission (FERC) licenses five hydroelectric dams in the middle Columbia reach (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids). FERC also licenses Idaho Power Company's (IPC) operation of Hells Canyon Complex. These projects are owned and operated, in no particular order, by Chelan, Douglas, Grant County Public Utility Districts (PUD), as well as by Idaho Power Company.

In 2002, NOAA Fisheries entered in to three site-specific 50-year anadromous fish agreements and HCPs, one for each of the three mainstem Columbia River projects owned by Chelan (Rocky Reach and Rock Island) and Douglas (Wells) County PUDs, pursuant to section 10 of the ESA. The HCPs are intended to protect spring-run Chinook, summer and fall-run Chinook, sockeye, steelhead, and coho. The HCPs satisfy the PUDs' anadromous salmonid obligations under the Federal Power Act, Fish and Wildlife Coordination Act, Pacific Northwest Magnuson-Stevens Fishery Conservation and Management Act, Title 77 RCW, and the ESA. These agreements set a "no net impact" standard to protect salmon and steelhead. Each of the three HCPs establishes a 91% standard of combined adult and juvenile passage survival at each project. The combined survival standard is composed of 93% juvenile and 98% adult for all salmonids. This is estimated to represent a 22 to 45% survival improvement potential over the survival levels observed under the historical operations of these projects.

In 2004, Grant County entered into a new FERC license that includes the following site-specific measures to ensure that the survival standards (articulated above) are met:

- Downstream passage measures, including spill through existing and top spill through future units; turbine operations and the installation of advanced turbines; total dissolved gas abatement; avian predator control; and a northern pikeminnow removal program
- Continued operation and maintenance, and where needed, improvements to adult fishways at both Priest Rapids and Wanapum dams
- Design and construction of an off-ladder trap and fish-handling facility at Priest Rapids Dam
- Sluiceway operations for steelhead fallbacks (kelts)
- The relicensing of the Hells Canyon Hydroelectric Project is the subject of ongoing FERC proceedings. At present, IPC voluntarily operates the project to protect habitat used by fall Chinook. As part of an interim settlement agreement in the license proceedings, IPC has agreed to release about 237 thousand kaf of water to improve downstream migration conditions for juvenile fall Chinook (Tucker 2005).

Survival Rates at Mainstem Federal & Non-Federal Projects

Adult Survival - Federal Projects

Adult survival estimates are based primarily on a "conversion rate" method which relies upon the detection and subsequent re-detection of PIT tagged "known-origin" adults as they migrate upstream through the fishways at the mainstem hydropower projects. For a full description of the methods used for these estimates please see Section 4.1 of the Hydro Module. Under the 2008 FCRPS biological opinion, the Action Agencies are responsible for ensuring that the high rates of survival currently observed in the Bonneville Dam to Lower Granite Dam (7 dams) reach for Snake River spring Chinook and steelhead is maintained or increased through 2018.

The average survival estimates are as follows (Federal projects):

- The average survival estimate for Snake River fall Chinook salmon between Bonneville Dam and Lower Granite Dam was 81% for those that migrated in-river as juveniles and approximately 75% for those that were transported as juveniles, equating to a per project survival (7 dams) of 97% and 96%, respectively.
- The average survival estimate for Snake River spring/summer Chinook salmon between Bonneville and Lower Granite dams was 91% for those that migrated in-river as juveniles and approximately 84% for those that were transported as juveniles, equating to a per project survival (7 dams) of 99% and 98%, respectively.
- The estimated average survival of Snake River sockeye between Bonneville Dam and Lower Granite dams was 81% equating to a per project survival (7 dams) of approximately 97%. No estimate can be made with the available data for those fish transported as juveniles.
- The average survival estimate for Snake River steelhead between Bonneville and Lower Granite dams was 90% for those that migrated in-river as juveniles and approximately 83% for those that were transported as juveniles, equating to a per project survival (7 dams) of 99% and 97%, respectively.
- The average survival estimate for Upper Columbia River spring Chinook between Bonneville and McNary dams was 90% (all of these fish migrate in-river as juveniles equating to a per project survival (3 dams) of approximately 97%.
- The average survival estimate for Upper Columbia River steelhead between Bonneville and McNary dams was 85% (all of these fish migrate in-river as juveniles), equating to a per project survival (3 dams) of 95%.

Adult Survival - Non-Federal Projects

- The average survival estimate for Upper Columbia River spring Chinook migrating between Priest Rapids and the Wenatchee, Entiat, and Methow rivers is approximately 95%, 96%, and 97%, respectively. This survival multiplied by the Bonneville to McNary survival estimate yields a Bonneville to Wenatchee, Entiat, and Methow river survival estimate of approximately 85%, 87%, and 88%.
- The average survival estimate for Upper Columbia River steelhead migrating between Priest Rapids and the Wenatchee, Entiat, and Methow rivers is approximately 93%, 95%, and 96%, respectively. This survival multiplied by the Bonneville to McNary survival estimate yields a Bonneville to Wenatchee, Entiat, and Methow river survival estimate of approximately 79%, 80%, and 82%.

Hydropower Module Summary

Juvenile Survival – All Projects

Juvenile survival levels are estimated for two periods. The "Current" scenario generally translates to survivals recently observed or estimated to have occurred due to operational and configuration changes at the mainstem hydroelectric projects through 2006. The "Prospective" scenario generally translates to attaining survival levels that are required by HCPs for the Wells, Rocky Reach, and Rock Island projects; the 2008 biological opinion for the Priest Rapids project; or modeled using COMPASS for the 2008 FCRPS biological opinion. Full attainment of these standards is expected when the FCRPS opinion is fully implemented between 2015 and 2018.

Juvenile Survival - Current

Estimates of juvenile survival through the federal projects, ranges of expected survival, and proportion of juveniles expected to be transported are broken into two categories: expected average flows at Lower Granite Dam (LGR) of less than 65 kcfs or greater than 65 kcfs for Snake River species. For full details, please see Table 2 of the Hydro Module. The results are as follows:

- The average juvenile survival estimate for Snake River spring/summer Chinook is 56% in the LGR less than 65 kcfs years and 37% in the LGR greater than 65 kcfs years. Estimates of the proportion transported are approximately 64% and 95% in these flow conditions, respectively.
- The average juvenile survival estimates of Snake River steelhead is 39% in the LGR less than 65 kcfs years and 8% in the LGR greater than 65 kcfs years. Estimates of the proportion transported are approximately 79% and 94% in these flow conditions, respectively.
- The average juvenile survival estimate for Upper Columbia River spring Chinook is 67% through the four FCRPS dams in the lower Columbia River, and 68%, 71%, and 77% for juveniles migrating the Methow, Entiat, and Wenatchee rivers through the three to five middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 45%, 47%, and 51%, respectively.
- The average juvenile survival estimate for Upper Columbia River steelhead is 48% through the four FCRPS dams in the lower Columbia River, and 69%, 72%, and 75% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 33%, 34%, and 36%, respectively.

Juvenile Survival - Prospective

Estimates of prospective juvenile survival through the federal projects, ranges of expected survival, and proportion of juveniles expected to be transported are broken into two categories: expected average flows at Lower Granite Dam (LGR) of less than 65 kcfs or greater than 65 kcfs. For full details, please see Table 3 of the Hydro Module. The results are as follows:

- The average juvenile survival estimate for Snake River spring/summer Chinook salmon is 63% in the LGR less than 65 kcfs years and 52% in the LGR greater than 65 kcfs years. Estimates of the proportion transported are approximately 64% and 95% in these flow conditions, respectively.
- The average juvenile survival estimate for Snake River steelhead is 45% in the LGR less than 65 kcfs years and 9% in the LGR greater than 65 kcfs years. Estimates of the proportion transported are approximately 74% and 89% in these flow conditions, respectively.
- The average juvenile survival estimate for Upper Columbia River spring Chinook is 73% through the four FCRPS dams in the lower Columbia River, and 72%, 75%, and 81% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 53%, 55%, and 59%, respectively.
- The average juvenile survival estimate for Upper Columbia River steelhead is 53% through the four FCRPS dams in the lower Columbia River, and 75%, 78%, and 81% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 40%, 41%, and 43%, respectively.

For More Information

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