APPENDIX G

INFORMATION ABOUT THE STATUS OF COLUMBIA RIVER SALMON AND STEELHEAD ESUs FROM THE NMFS 2005 UPPER SNAKE RIVER BIOLOGICAL OPINION

STATUS OF COLUMBIA RIVER SALON AND STEELHEAD ESUS AND FACTORS AFFECTING SALMON AND STEELHEAD IN THE ACTION AREA

(excerpt from March 31, 2005, NMFS Biological Opinion on the U.S. Bureau of Reclmation's Upper Snake River Basin Projects)

4.3.1 SR Spring/Summer Chinook Salmon

4.3.1.1 ESU Structure

Based on genetic and geographic considerations, the Interior TRT (2003) established five major population groups in this ESU: the Lower Snake River Tributaries, the Grande Ronde and Imnaha Rivers, the South Fork Salmon River, the Middle Fork Salmon River, and the Upper Salmon River. The Interior TRT further subdivided these groupings into a total of 31 extant, demographically independent populations (Appendix B, Figure B-1). However, Chinook salmon have been extirpated from the Snake River and its tributaries above Hells Canyon Dam, an area that encompassed about 50% of the pre-European spawning areas in the Snake River Basin (NRC 1996). Major subbasins in the Clearwater were blocked to Chinook salmon in 1927 by the Lewiston Dam. Although the number of spring-run spawning aggregations that were lost due to construction of the Snake River mainstem dams is unknown, the ESU still has a wide spatial distribution in a variety of locations and habitat types.

4.3.1.2 The BRT Findings

NMFS recently conducted a status review of the SR spring/summer Chinook salmon and other ESUs. As part of that status review, NMFS convened a BRT to evaluate the available scientific data. The BRT analysis included dam counts and spawner returns for natural-origin fish through 2001. As indicated in Section 1, NMFS must examine the criteria for a sufficient number and distribution of VSPs in order to assess the range-wide biological requirements of the ESU. The BRT did the same thing in assessing whether or not the ESU should be listed as an endangered or threatened species. In this case, the BRT found that, compared to the levels needed for a healthy species, there was a moderately high risk that the abundance and productivity criteria were not currently being met and a low risk that the spatial structure and diversity criteria were not currently being met. Concerns regarding diversity were somewhat alleviated, because out-of- ESU Rapid River broodstock had been phased out of the Grande Ronde. Despite the recent positive signs, the BRT still felt that the ESU was at some level of risk.

4.3.1.3 2004 Status Review

An indicator of the current range-wide status of this ESU is the number of spawners returning to natural production areas. In 1995, NMFS established abundance levels for natural production areas that would be indicative of a recovered population (NMFS 1995b), and these levels were updated as "interim abundance and productivity targets" in 2002 (NMFS 2002). Many, but not all of the 29 extant natural production areas within this ESU have experienced large increases in the number of returning spawners in the last 2 to 3 years, with two populations (Grande Ronde and Imnaha) nearing the previously specified recovery abundance levels. Due to the severe declines in the populations since the 1960s and the short-term nature of the recent high returns, long-term productivity trends remain below replacement for all natural production areas, despite the recent increases. However, the short-term productivity trends for the majority of the natural production areas in the ESU are at or above replacement, which is a positive sign.

During the Status Review, NMFS evaluated whether conservation efforts, such as the extensive artificial propagation program, within this ESU reduced or eliminated the risk to SR spring/summer Chinook salmon. In performing this analysis, NMFS was guided by the NMFS/USFWS "Policy for Evaluation of Conservation Efforts When Making Listing Decisions" ("PECE," 68 FR 15100; March 28, 2003). NMFS concluded that the artificial propagation programs did provide benefits to the ESU in terms of abundance, spatial structure, and diversity, but that the programs had neutral or uncertain effects in terms of overall ESU productivity. As a result, NMFS did not believe that the artificial propagation programs were

sufficient to substantially reduce the long-term extinction risk of the ESU. Thus, even though the ESU is likely to benefit from strong upcoming brood years,[147] NMFS proposed to retain the current listing of this species as threatened (i.e., likely to become an endangered species within the foreseeable future). Actions under the 2000 FCRPS Biological Opinion and improvements in hatchery practices are addressing some of the ESU's factors for decline.

4.3.1.4 Recent Dam Counts and Returns to the Spawning Grounds

Cooney (2004) updated the spawner count data used by the BRT (2003) for use by the Interior Columbia Basin TRT, adding data for 2002 and 2003, which he requested from the co-managers. In general, for most of the 24 populations where recent data were available, indices of abundance (i.e., redd counts) for natural-origin SR spring/summer Chinook salmon were high in 2002 and 2003 compared to the 1990s. Fisher and Hinrichsen (2004) provided a preliminary evaluation of the effects of recent natural-origin spring Chinook salmon returns on past geometric mean abundance levels and population trends. The latter were calculated as the slope of the regression line for the (log transformed) index of abundance over time. They assessed whether the geomean was greater when calculated from the most recent data (beginning in 2001) compared to a base period (1996-2000) and whether the trend was greater when counts for 2001-2003 were added to the 1990-2000 data series. Their methods were taken from those used by NMFS' BRT (2003). The geomean for 2001-2003 (33,581) exhibited a 548% increase over the 1996-2000 base period (5,186 fish). The slope of the trend for the natural-origin population increased 17% (from 0.97 to 1.14) when the data for 2001-2003 were added to the 1990-2000 series, reversing the decline and indicating that, at least for the short-term, the natural-origin population has been increasing. Hatchery fish constituted 69% of the return during the recent period compared to an average of 60% during 1990-2000 (Fisher 2004). Even so, natural-origin fish exhibited the substantial increase in numbers described above. Neither the BRT nor the Interior TRT has reviewed Fisher and Hinrichsen (2004) or Fisher (2004).

4.3.2 SR Fall Chinook Salmon

4.3.2.1 ESU Structure

A majority of the fish in this ESU spawn in the mainstem Snake River between the head of Lower Granite Reservoir and Hells Canyon Dam, with the remaining fish distributed among lower sections of the major tributaries (Connor et al. 2002). Fish in the mainstem Snake appear to be distributed in a series of aggregates from the mouth of Asotin Creek to River Mile (RM) 219, although smaller numbers have been reported spawning in the tailraces of the Lower Snake dams (Connor et al. 1993; Dauble et al. 1995). Due to their proximity and the likelihood that individual tributaries could not support a sufficiently large population, the Interior TRT (2003) considered these aggregates and the associated reaches in the lower major tributaries to the Snake to be a single population (Appendix B, Figure B-2). This is consistent with past practice in prior biological opinions.

Before European impact, Snake River fall Chinook salmon are believed to have once occupied and spawned in the mainstem Snake River from its confluence with the Columbia River upstream to Shoshone Falls (RM 615). The spawning grounds between Huntington, Oregon (RM 328) and Auger Falls in Idaho (RM 607) were historically the most important for this species. Historically, only limited spawning activity occurred downstream of RM 273 (Waples et al. 1991), which is about one mile below Oxbow Dam. However, the development of irrigation and hydropower projects on the mainstem Snake River has inundated or blocked access to most of this area in the past century. Construction of Swan Falls Dam (RM 458) in 1901 eliminated access to 157 miles (about 25%) of total potential habitat, leaving 458 miles of habitat. Construction of the Hells Canyon Dam complex (1958-1967) cut off anadromous fish access to 211 miles (or 46%) of the remaining historical fall Chinook salmon habitat upstream of RM

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[147] That is, the upcoming brood years were derived from strong spawning escapements and improved conditions during the ocean phase of the life cycle.

247. Additional fall Chinook salmon habitat was lost through inundation as a result of the construction of the four lower mainstem Snake River dams. Currently, SR fall Chinook salmon have access to approximately 100 miles of mainstem Snake River habitat, which is roughly 22% of the 458 miles of historical habitat available prior to completion of the Hells Canyon Complex and the four lower Snake River dams. Historical use of habitat in the Clearwater River is uncertain. Tiffan et al. (2001) concluded that there was "no conclusive evidence" whether the lower Clearwater River supported the basin subyearling migrant life-history pattern associated with Snake River fall Chinook salmon.

4.3.2.2 The BRT Findings

Approximately 80% of historical spawning habitat was lost with the construction of a series of dams on the mainstem Snake River. The loss of spawning habitat, restricting the extant ESU to a single naturally spawning population, increased the ESU's vulnerability to environmental variability and catastrophic events. The diversity associated with populations that once resided above the Snake River dams has been lost, and the impact of out-of-ESU fish straying to the spawning grounds has the potential to further compromise the genetic diversity of the ESU. Although recent improvements in the marking of out-of-ESU hatchery fish and their removal at Lower Granite Dam have reduced the impact of these strays, introgression below Lower Granite Dam remains a concern. The BRT found moderately high risk for all VSP categories and therefore felt that, despite the recent positive signs, the ESU was at some level of risk.

4.3.2.3 2004 Status Review

During the Status Review, NMFS evaluated whether artificial propagation programs within this ESU reduce or eliminate risks to its viability, guided by the PECE policy (Section 4.3.1). NMFS concluded that the artificial propagation programs have provided benefits to the ESU in terms of abundance, spatial distribution, and diversity in recent years, although the contribution of these programs to overall ESU productivity is uncertain and the artificial propagation programs are not sufficient to substantially reduce the long-term risk of extinction. Depending upon the assumption made about the likelihood of the progeny of hatchery fish returning as productive adults, long- and short-term trends in productivity are at or above replacement. Thus, NMFS proposed to retain the current listing of this species as threatened (i.e., likely to become an endangered species within the foreseeable future) even though it is not likely to go extinct in the near future. Actions under the 2000 FCRPS Biological Opinion and improvements in hatchery practices have provided some encouraging signs in addressing the ESU's factors for decline.

4.3.2.4 Recent Dam Counts and Returns to the Spawning Grounds

Cooney (2004) reported that the high counts of natural-origin SR fall Chinook salmon continued in 2002 and 2003 (2,114 and 3,896 adults at Lower Granite Dam, respectively). In their preliminary analysis of recent returns, Fisher and Hinrichsen (2004) reported that the geometric mean abundance of naturally-produced fall Chinook salmon was 3,462 during 2001-2003, compared to 694 in 1996-2000 (a 398% increase). The slope of the population trend increased 8.0% (from 1.16 to 1.24) when the data for 2001-2003 were added to the 1990-2000 series. These results indicate that, at least for the short-term, the population has been increasing. Approximately 64% of the aggregate run at Lower Granite Dam was hatchery fish in 2001-2003, compared to 67% during 1990-2000 (Fisher 2004).

4.3.3 UCR Spring Chinook Salmon

4.3.3.1 ESU Structure

The Interior TRT (2003) identified one major population group consisting of three demographically independent populations in the UCR spring Chinook salmon ESU (Appendix B, Figure B-3). Due to the relatively small size of the area, they did not identify any major groupings. Within the current boundary of the ESU, spring Chinook salmon are considered extirpated from the Okanogan drainage. The historical status of spring-run, stream-type fish belonging to this ESU in the Okanogan is uncertain. The Interior TRT could not determine definitively whether an independent population of UCR spring Chinook salmon existed there in the past but recognized the possibility that the area may have supported one. The

construction of Grand Coulee Dam in 1939 blocked access to over 50% of the river miles formerly available to UCR spring Chinook salmon (NRC 1996). Tributaries in this blocked area may have supported one or more populations, but the lack of data on distribution and genetic makeup made it impossible for the Interior TRT to make any definitive determination.

4.3.3.2 The BRT Findings

The five hatchery spring-run Chinook salmon populations considered to be part of this ESU are programs aimed at supplementing natural production areas. These programs have contributed substantially to the abundance of natural spawners in recent years. However, little information is available to assess the impact of these high levels of supplementation on the long-term productivity of natural populations. The BRT (2003) concluded that spatial structure in this ESU was of little concern, because there is passage and connectivity among almost all populations. During years of critically low escapement (1996 and 1998), extreme management measures were taken in one of the three major spring Chinook salmon producing basins where all returning adults were collected and taken into the hatchery supplementation programs, reflecting the ongoing vulnerability of certain segments of this ESU. The BRT expressed concern that these actions, while appropriately guarding against the catastrophic loss of populations, may have compromised ESU population structure and diversity. The BRT's assessment of risk for the four VSP categories reflects strong concerns regarding abundance and productivity and comparatively less concern for ESU spatial structure and diversity (BRT 2003).

4.3.3.3 2004 Status Review

In its Status Review, NMFS' assessment of the effects of artificial propagation concluded that the within-ESU hatchery programs do not substantially reduce the extinction risk of the ESU in total (NMFS 2004c). Protective efforts, as evaluated pursuant to the PECE, did not alter NMFS' assessment that the ESU is in danger of extinction or likely to become so in the foreseeable future. Actions under the 2000 FCRPS Biological Opinion, Federally funded habitat restoration efforts, and other protective efforts are encouraging signs in addressing the ESU's factors for decline, but they do not as yet substantially reduce the ESU's extinction risk. Artificial propagation practices within the geographic range of the ESU do not fully support the conservation and recovery of UCR spring-run Chinook salmon. In particular, NMFS is concerned that the non-ESU Entiat National Fish Hatchery has compromised the genetic integrity of the native natural population of spring-run Chinook salmon in the Entiat Basin.

4.3.3.4 Recent Dam Counts and Returns to the Spawning Grounds

Cooney (2004) reported that natural-origin returns to the Methow subbasin in 2002 and to the Entiat and Wenatchee during 2002 and 2003 continued to exceed those observed during much of the 1990s. However, returns to the Methow declined during 2003. In their preliminary analysis, Fisher and Hinrichsen (2004) reported that the geometric mean of aggregate numbers of UCR spring Chinook salmon increased 1,038% from 1996-2000 (4,959) to 2001-2003 (436 fish). The slope of the aggregate population trend increased 9.3% (from 1.00 to 1.10) when the data for 2001-2003 were added to the 1990-2000 series. These results indicate that, at least in the short term, the aggregate population and the natural-origin populations in the Entiat and Wenatchee subbasins have been increasing.

4.3.4 UWR Chinook Salmon

4.3.4.1 ESU Structure

The Willamette/Lower Columbia River (W/LC) TRT (McElhany et al. 2004) identified seven demographically independent populations of UWR Chinook salmon in a single major group (Appendix B, Figure B.4). All of these populations are extant, although they vary in degree of viability.

4.3.4.2 The BRT Findings

Numbers passing Willamette Falls have remained relatively steady over the past 50 years (ranging from approximately 20,000 to 75,000), but are an order of magnitude below the peak abundance levels

observed in the 1920s (approximately 300,000 adults). The Clackamas and McKenzie River populations have shown substantial increases in total abundance since 2000. Trends in the other populations are difficult to determine. However, interpretation of the difference in abundance levels for the other populations remains confounded by a high but uncertain fraction of hatchery-origin fish.

The BRT estimated that, despite improving trends in total productivity since 1995, productivity would be below replacement in the absence of artificial propagation. The BRT was particularly concerned that a majority of the historical spawning habitat and approximately 30% to 40% of total historical habitat are now inaccessible behind dams. The restriction of natural production to just a few areas increases the ESU's vulnerability to environmental variability and catastrophic events. Losses of local adaptation and genetic diversity through the mixing of hatchery stocks within the ESU and the introgression of out-of-ESU hatchery fall-run Chinook salmon represent threats to ESU diversity. However, the BRT was encouraged by the recent closure of the fall-run hatchery and by improved marking rates of hatchery fish to assist in monitoring and in the management of a marked-fish selective fishery. The BRT found moderately high risks for all VSP categories.

4.3.4.3 2004 Status Review

There are no direct estimates of total natural-origin spawner abundance for the UWR Chinook salmon ESU. The abundance of the aggregate run passing Willamette Falls has remained relatively steady over the past 50 years (ranging from approximately 20,000 to 70,000 fish), but is only a fraction of peak abundance levels observed in the 1920s (approximately 300,000 adults). Interpretation of abundance levels is confounded by a high but uncertain fraction of hatchery-produced fish. The McKenzie River population has shown substantial increases in total abundance (hatchery origin and natural origin fish) in the last 2 years, while trends in other natural populations in the ESU are generally mixed. With the relatively large incidence of hatchery fish spawning in the wild, it is difficult to determine trends in productivity for natural origin fish.

Seven artificial propagation programs in the Willamette River produce fish that are considered to be part of the UWR Chinook salmon ESU. All of these programs are funded to mitigate for lost or degraded habitat and produce fish for harvest purposes. During the Status Review, NMFS' assessment of the effects of artificial propagation concluded that these hatchery programs collectively do not substantially reduce the extinction risk of the ESU (NMFS 2004c). An increasing proportion of hatchery-origin returns has contributed to increases in total ESU abundance. However, it is unclear whether these returning hatchery and natural fish actually survive over winter to spawn. Estimates of pre-spawning mortality indicate that a high proportion (more than 70%) of spring Chinook salmon in most ESU populations die before spawning. In recent years, hatchery fish have been used to reintroduce spring Chinook salmon back into historical habitats above impassible dams (e.g., in the North Santiam, McKenzie, and Middle Fork Willamette Rivers), slightly decreasing risks to ESU spatial structure. Within-ESU hatchery fish exhibit different life-history characteristics from natural ESU fish. High proportions of hatchery-origin natural spawners in remaining natural production areas (i.e., in the Clackamas and McKenzie Rivers) may thereby have negative impacts on within- and among population genetic and life-history diversity. Collectively, artificial propagation programs in the ESU have a slight beneficial effect on ESU abundance and spatial structure but neutral or uncertain effects on ESU productivity and diversity. Protective efforts, as evaluated pursuant to the PECE, did not alter the assessments of the BRT and the Artificial Propagation Evaluation Workshop participants that the ESU is "likely to become endangered within the foreseeable future." The USFWS Greenspaces Program, the Oregon Plan, hatchery reform efforts, and other protective initiatives are encouraging signs. However, restoration efforts in the ESU are very local in scale and have yet to provide benefits at the scale of watersheds or at the larger spatial scale of the ESU. The blockage of historical spawning habitat and the restriction of natural production areas remain to be addressed.

4.3.4.4 Recent Dam Counts and Returns to the Spawning Grounds

Fisher and Hinrichsen (2004) report that the preliminary geometric mean aggregate abundance of UWR Chinook salmon in the Clackamas and McKenzie Rivers is equal to 12,530 for 2001-2003, compared to 3,041 in 1996-2000, a 312% increase. The slope of the aggregate population trend increased 15.2% (from 0.89 to 1.02) when the data for 2001-2003 were added to the 1990-2000 series, reversing the decline and indicating that, at least in the short-term, the aggregate population has been increasing.

4.3.5 LCR Chinook Salmon

4.3.5.1 ESU Structure

The W/LC TRT (McElhany et al. 2004) identified a total of 23 extant, demographically independent populations in six major population groups: the Coastal fall-run, Cascade fall-run, Cascade late fall-run, Cascade spring-run, Gorge fall-run, and Gorge spring-run (Appendix B, Figures B.5a and B.5b).

4.3.5.2 The BRT Findings

Abundance estimates of naturally produced spring Chinook salmon have improved since 2001 due to the marking of all hatchery spring Chinook salmon releases (compared to a previous marking rate of only 1% to 2%), which allows for the separation in counts at weirs and traps and on spawning grounds. Despite recent improvements, long-term trends in productivity are below replacement for the majority of populations. Of the historical populations, 8 to 10 have been extirpated or nearly extirpated. Although approximately 35% of historical habitat has been lost behind impassable barriers, the ESU exhibits a broad spatial distribution in a variety of watersheds and habitat types. Natural production currently occurs in approximately 20 populations, although only one population has a mean spawner abundance exceeding 1,000 fish. The BRT expressed concern that most of the extirpated populations are spring-run, and the disproportionate loss of this life history type represents a risk to ESU diversity. Additionally, of the 4 hatchery spring-run Chinook salmon populations considered to be part of the ESU, 2 are propagated in rivers that, although they are within the historical geographic range of the ESU, probably did not support spring-run populations. High hatchery production poses genetic and ecological risks to the natural populations and complicates assessments of their performance. The BRT also expressed concern over the introgression of out-of-ESU hatchery stocks. The BRT found moderately high risk for all VSP categories.

4.3.5.3 2004 Status Review

In its Status Review, NMFS notes that many populations within the LCR Chinook salmon ESU have exhibited pronounced increases in abundance and productivity in recent years, possibly due to improved ocean conditions. Abundance estimates of naturally spawned populations have been uncertain until recently due to a high (approximately 70%) fraction of naturally spawning hatchery fish. Abundance estimates of naturally-produced spring Chinook salmon have improved since 2001 due to the marking of all hatchery spring Chinook salmon releases (compared to a previous marking rate of only 1% to 2%), which allows for the separation in counts at weirs and traps and on spawning grounds. Despite recent improvements, long-term trends in productivity through 2001 were below replacement for the majority of populations in the ESU. Of the historical populations, 8 to 10 were extirpated or nearly extirpated. Although approximately 35% of historical habitat is behind impassable barriers, the ESU exhibits a broad spatial distribution in a variety of watersheds and habitat types. Natural production occurs in approximately 20 populations, although as of 2001, only one population had a mean spawner abundance exceeding 1,000 fish.

Seventeen artificial propagation programs releasing hatchery Chinook salmon are considered part of the LCR Chinook salmon ESU. All of these programs are designed to produce fish for harvest, and three of these programs are also intended to augment naturally spawning populations in the basins where the fish are released. These three programs integrate naturally produced spring Chinook salmon into the broodstock in an attempt to minimize the genetic effects of returning hatchery adults that spawn in the

wild.

During the 2004 Status Review, NMFS' assessment of the effects of artificial propagation concluded that these hatchery programs do not substantially reduce the extinction risk of the ESU in total (NMFS 2004c). Although the hatchery programs have been successful at producing substantial numbers of fish, thereby reducing risks to ESU abundance, their effect on the productivity of the ESU in total is uncertain. Additionally, the high level of hatchery production in this ESU poses potential genetic and ecological risks to the ESU and confounds the monitoring and evaluation of abundance trends and productivity. The Cowlitz River spring Chinook salmon program releases parr into the Upper Cowlitz River Basin in an attempt to reestablish a naturally spawning population above Cowlitz Falls Dam. Such reintroduction efforts increase the ESU's spatial distribution into historical habitats and slightly reduce risks to ESU spatial structure. The few programs that regularly integrate natural fish into the broodstock may help preserve genetic diversity within the ESU. However, the majority of hatchery programs in the ESU have not converted to the practice of regularly incorporating natural broodstock, thus limiting this risk-reducing feature at the ESU scale. Past and ongoing transfers of broodstock among hatchery programs in different basins represent risks to within- and among-population diversity. Collectively, artificial propagation programs in the ESU provide slight benefits to ESU abundance, spatial structure, and diversity but have neutral or uncertain effects on productivity.

NMFS' assessment of the effects of artificial propagation concluded that the within-ESU hatchery programs do not substantially reduce the risk of the ESU in total (NMFS 2004c). Protective efforts, as evaluated pursuant to the PECE, did not alter NMFS' assessment that the ESU is "likely to become endangered within the foreseeable future." Planned dam removals on the Sandy River, Federally funded habitat restoration efforts, the Washington Department of Natural Resources HCP, and other protective efforts are encouraging signs that the ESU's factors for decline are being addressed, but they do not as yet substantially reduce threats to the ESU.

4.3.5.4 Recent Dam Counts and Returns to the Spawning Grounds

Fisher and Hinrichsen (2004) compared the aggregate abundance of 41,450 during 2001 to a geomean of 11,135 for the years 1996-2000, a 272% increase. The slope of the aggregate population trend increased 6.6% (from 0.76 to 1.03) when the count for 2001 was added to the 1990-2000 data series, reversing the decline and indicating that, at least in the short-term, the aggregate population is increasing.

4.3.6 SR Steelhead

4.3.6.1 ESU Structure

The Interior TRT (2003) identified 23 populations[148] in 6 major population groups in this ESU: the Clearwater River, the Grande Ronde River, Hells Canyon, the Imnaha River, the Lower Snake River, and the Salmon River (Appendix B, Figure B.6). Like SR spring/summer Chinook salmon, SR steelhead were blocked from portions of the Upper Snake River beginning in the late 1800s and culminating with the construction of Hells Canyon Dam in the 1960s. The SR steelhead ESU includes all naturally spawned populations of steelhead (and their progeny) in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho (62 FR 43937; August 18, 1997).

NMFS' June 14, 2004, listing proposal did not resolve the ESU membership of native resident populations that are above recent (usually manmade) impassable barriers but below natural barriers. It was provisionally proposed that these resident populations not be considered part of the revised SR steelhead ESU until such time as significant scientific information becomes available to afford a case-by-

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[148] The Interior TRT (2003) identified one additional group of tributaries, Hells Canyon, which members thought was not large enough to support a demographically independent population.

case evaluation of their ESU relationships. There was one exception in the listing proposal: recent genetic data suggest that native resident steelhead above Dworshak Dam on the North Fork Clearwater River are part of the ESU. However, NMFS did not propose that hatchery rainbow trout introduced to the Clearwater River (and other areas within the ESU) be included in the ESU. The presence of 6 major population groups in this ESU means that it is less likely that any single group is significant for this ESU's survival and recovery, compared to ESUs with fewer major population groups.

4.3.6.2 The BRT Findings

The BRT (2003) noted that the ESU remains spatially well distributed in each of the six major geographic areas in the Snake River Basin. However, the Snake River Basin steelhead "B run"[149] was particularly depressed. The BRT was also concerned about the predominance of hatchery origin fish in this ESU, the inferred displacement of naturally produced fish by hatchery-origin fish, and potential impacts on ESU diversity. High straying rates exhibited by some hatchery programs generated concern about the possible homogenization of population structure and diversity. However, recent efforts to improve the use of local broodstock and release hatchery fish away from natural production areas are encouraging. For many BRT members, the presence of relatively numerous resident fish reduces risks to ESU abundance but provides an uncertain contribution to ESU productivity, spatial structure, and diversity (NMFS 2003, 2004b). The BRT found moderate risk for the abundance, productivity, and diversity VSP categories and comparatively lower risk in the spatial structure category.

4.3.6.3 2004 Status Review

The paucity of information on adult spawning escapement for specific tributary production areas in the SR steelhead ESU made a quantitative assessment of viability difficult. Annual return estimates are limited to counts of the aggregate return over Lower Granite Dam, and spawner estimates for the Tucannon, Grande Ronde, and Imnaha Rivers. The 2001 return over Lower Granite Dam was substantially higher relative to the low levels seen in the 1990s; the recent 5- year mean abundance (14,768 natural returns) approximately 28% of the interim recovery target level. The abundance surveyed in sections of the Grande Ronde, Imnaha, and Tucannon Rivers was generally improved in 2001. However, recent 5-year abundance and productivity trends (through 2001) were mixed. Five of the nine available data series exhibit positive long- and short-term trends in abundance. The majority of long-term population growth rate estimates for the nine available series were below replacement. The majority of short-term population growth rates (through 2001) were marginally above replacement or well below replacement, depending upon the assumption made regarding the effectiveness of hatchery fish in contributing to natural production.

There are six artificial propagation programs producing steelhead in the Snake River Basin that are considered to be part of the ESU. Artificial propagation enhancement efforts occur in the Imnaha River (Oregon), Tucannon River (Washington), East Fork Salmon River (Idaho, in the initial stages of broodstock development), and South Fork Clearwater River (Idaho). In addition, Dworshak Hatchery acts as a gene bank to preserve the North Fork Clearwater River "B-run" steelhead population, which no longer has access to historical habitat due to construction of Dworshak Dam. During the Status Review, NMFS' assessment of the effects of artificial propagation concluded that these hatchery programs collectively do not substantially reduce the extinction risk of the ESU in total (NMFS 2004c). Snake River Basin hatchery programs may be providing some benefit to the local target, but only the Dworshak-based programs have appreciably benefited the total number of adult spawners. The Little Sheep Hatchery program is contributing to total abundance in the Imnaha River but has not contributed to increased natural productivity. The Tucannon and East Fork Salmon River programs were only recently initiated

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[149] B-run steelhead have a 2-year ocean residence and larger body size and are believed to be produced only in the Clearwater, Middle Fork Salmon, and South Fork Salmon Rivers.

and have yet to produce appreciable adult returns. Thus, the overall contribution of the hatchery programs in reducing risks to ESU abundance is small, and the contribution of ESU hatchery programs to the productivity of the ESU in total is uncertain. Most returning Snake River Basin hatchery steelhead are collected at hatchery weirs or have access to unproductive mainstem habitats, limiting potential contributions to the productivity of the entire ESU. The artificial propagation programs affect only a small portion of the ESU's spatial distribution and confer only slight benefits to ESU spatial structure. Large steelhead programs not considered to be part of the ESU occur in the mainstem Snake, Grande Ronde, and Salmon Rivers and may adversely affect ESU diversity. These out-of-ESU programs are currently undergoing review to determine the level of isolation between the natural and hatchery stocks and to define what reforms may be needed. Collectively, artificial propagation programs in the ESU provide a slight beneficial effect to ESU abundance and spatial structure but have neutral or uncertain effects on ESU productivity and diversity.

4.3.6.4 Recent Dam Counts and Returns to the Spawning Grounds

The lack of information on adult spawning escapement to many tributary production areas makes it difficult to assess quantitatively the viability of the SR steelhead ESU. Estimates of annual returns are limited to estimates of aggregate numbers over Lower Granite Dam and spawner estimates for the Tucannon, Grande Ronde, and Imnaha Rivers. Cooney (2004) reported continuing high returns of natural-origin SR steelhead (both A- and B-run fish) during 2002 and 2003 compared to those observed during much of the 1990s. In their preliminary report, Fisher and Hinrichsen (2004) estimated that the geometric mean of the natural-origin run was 37,784 during 2001-2003, a 253% increase over the 1996-2000 period (10,694 steelhead). The slope of the population trend increased 9.3% (from 1.00 to 1.10) when the counts for 2001-2003 were added to the 1990-2000 data series. These data indicate that, at least in the short-term, the natural-origin run has been increasing.

4.3.7 UCR Steelhead

4.3.7.1 ESU Structure

The Interior TRT (2003) identified four historical, demographically independent populations in a single major population group in this ESU (Appendix B, Figure B.7). As described above for UCR spring Chinook salmon, the construction of Grand Coulee Dam in 1939 blocked access to over 50% of the river miles formerly available to UCR steelhead (NRC 1996). Tributaries in this blocked area may have supported one or more populations, but the lack of data on distribution and genetic makeup made it impossible for the Interior TRT to make a definitive determination. The UCR steelhead ESU includes all naturally spawned populations of steelhead in streams in the Columbia River Basin upstream from the Yakima River in Washington to the United States- Canada border (62 FR 43937; August 18, 1997).

NMFS' June 14, 2004, listing proposal did not resolve the ESU membership of native resident populations that are above recent (usually man-made) impassable barriers but below natural barriers. It was provisionally proposed that these resident populations not be considered part of the revised UCR steelhead ESU, until such time as significant scientific information becomes available, thereby affording a case-by-case evaluation of their ESU relationships.

4.3.7.2 The BRT Findings

The BRT (2003) was concerned about the general lack of detailed information regarding the productivity of natural populations. The extremely low replacement rate of naturally spawning fish (0.25-0.30 at the time of the last status review in 1998) does not appear to have improved appreciably. The predominance of hatchery-origin natural spawners (approximately 70% to 90% of adult returns) is a significant source of concern for the diversity of the ESU and generates uncertainty about long-term trends in natural abundance and productivity. The natural component of the anadromous run over Priest Rapids Dam has increased from an average of 1,040 (1992-1996) to 2,200 (1997-2001). This pattern, however, is not consistent for other production areas within the ESU. The mean proportion of natural-origin spawners

declined by 10% from 1992-1996 to 1997-2001. For many BRT members, the presence of relatively numerous resident fish reduced risks to ESU abundance but provided an uncertain contribution to ESU productivity, spatial structure, and diversity (NMFS 2003, 2004b). The BRT found high risk for productivity and comparatively lower risk for abundance, diversity, and spatial structure.

4.3.7.3 2004 Status Review

In its Status Review, NMFS reported that the last 2-3 years (through 2001) had seen an encouraging increase in the number of naturally produced fish in the UCR steelhead ESU. The 1996-2001 average aggregate return through the Priest Rapids Dam fish ladder (just below the upper Columbia steelhead production areas) was approximately 12,900 total adults, compared to 7,800 adults for 1992–1996. However, the recent 5-year mean abundances (through 2001) for naturally spawned populations in this ESU were 14% to 30% of their interim recovery target abundance levels.

Six artificial propagation programs that produce hatchery steelhead are considered to be part of the UCR steelhead ESU. These programs are intended to contribute to the recovery of the ESU by increasing the abundance of natural spawners, increasing spatial distribution, and improving local adaptation and diversity (particularly with respect to the Wenatchee River steelhead). Research projects to investigate the spawner productivity of hatchery-reared fish are being developed. Some of the hatchery-reared steelhead adults that return to the basin may be in excess of needs of the naturally spawning population in years when survival is high, potentially posing a risk to the natural-origin component of the ESU. The artificial propagation programs included in this ESU adhere to strict protocols for the collection, rearing, maintenance, and mating of the captive brood populations. Genetic evidence suggests that these programs remain closely related to the naturally spawned populations and maintain local genetic distinctiveness of populations within the ESU. HCPs with the Chelan and Douglas Public Utility Districts and binding mitigation agreements ensure that these programs will have secure funding and will therefore continue into the future. These hatchery programs have undergone ESA Section 7 consultation to ensure that they do not jeopardize the recovery of the ESU and have received ESA Section 10 permits for production though 2007. Annual reports and other specific information reporting requirements are used to ensure that the terms and conditions specified by NMFS are followed. These programs, through adherence to best professional practices, have not experienced disease outbreaks or other catastrophic losses.

During the Status Review, NMFS' assessment of the effects of artificial propagation concluded that hatchery programs collectively mitigate the immediacy of extinction risk for the UCR steelhead ESU in total in the short-term, but the contributions of these programs to the long-term survival and recovery of the species is uncertain (NMFS 2004c). The ESU hatchery programs substantially increase total ESU returns, particularly in the Methow Basin, where hatchery-origin fish make up an average of 92% of all returns. The contribution of hatchery programs to the abundance of naturally spawning fish is uncertain, as is their contribution to the productivity of the ESU in total. However, the presence of large numbers of hatchery-origin steelhead in excess of both broodstock needs and available spawning habitat capacity may decrease the productivity of the ESU. With increasing ESU abundance in recent years, naturally spawning, hatchery-origin fish have expanded into unoccupied spawning areas. Collectively, artificial propagation programs benefit ESU abundance and spatial structure but have neutral or uncertain effects on ESU productivity and diversity.

4.3.7.4 Recent Dam Counts and Returns to the Spawning Grounds

Fisher and Hinrichsen's (2004) preliminary estimate of the geometric mean of natural-origin UCR steelhead was 3,643 during 2001-2003, compared to 1,146 in 1996-2000, a 218% increase. The slope of the natural-origin population trend increased 9.2% (from 0.97 to 1.06,) when the data for 2001-2003 were added to the 1990-2000 series, reversing the decline and indicating, at least in the short-term, that the run size has been increasing.

4.3.8 MCR Steelhead

4.3.8.1 ESU Structure

The Interior TRT (2003) identified 15 populations in 4 major population groups (Cascades Eastern Slopes Tributaries, John Day River, the Walla Walla and Umatilla Rivers, and the Yakima River) and 1 unaffiliated independent population (Rock Creek) in this ESU (Appendix B, Figure B.8). There are 2 extinct populations in the Cascades Eastern Slope major population group (MPG), the White Salmon and Deschutes Rivers above Pelton Dam.

The MCR steelhead ESU includes all naturally spawned populations of steelhead in streams from above the Wind River in Washington and the Hood River in Oregon (exclusive), upstream to and including the Yakima River in Washington, excluding steelhead from the Snake River Basin (64 FR 14517; March 25, 1999).

NMFS' June 14, 2004, listing proposal did not resolve the ESU membership of native resident populations that are above recent (usually manmade) impassable barriers but below natural barriers. It was provisionally proposed that these resident populations not be considered part of the revised MCR steelhead ESU until such time as significant scientific information becomes available, thereby affording a case-by-case evaluation of their ESU relationships.

4.3.8.2 The BRT Findings

The continued low number of natural returns to the Yakima River (10% of the interim recovery target abundance level, for a subbasin that was a major historical production center for the ESU) generated concern in the BRT. However, steelhead remain well distributed in the majority of subbasins in the ESU. The presence of substantial numbers of out-of-basin (and largely out-of- ESU) natural spawners in the Deschutes River raised substantial concern regarding the genetic integrity and productivity of the native Deschutes population. The extent to which this straying is a historical natural phenomenon is unknown. The cool Deschutes River temperatures may attract fish migrating in the comparatively warm Columbia River, inducing high stray rates. The BRT noted a particular difficulty in evaluating the contribution of resident fish to ESU-level extinction risk. Several sources indicate that resident fish are very common in the ESU and may greatly outnumber anadromous fish. The BRT concluded that the relatively abundant and widely distributed resident fish in the ESU reduce risks to overall ESU abundance but provide an uncertain contribution to ESU productivity, spatial structure, and diversity (NMFS 2003, 2004b).

4.3.8.3 2004 Status Review

In its Status Review, NMFS noted that the abundance of natural populations in the MCR steelhead ESU increased substantially in 2001 over the previous 5 years. The Deschutes and Upper John Day Rivers had recent 5-year mean abundance levels in excess of their respective interim recovery target abundance levels (NMFS 2002). Due to an uncertain proportion of out-of-ESU strays in the Deschutes River, the recent increases in this population were difficult to interpret.

There are seven hatchery steelhead programs considered to be part of the MCR steelhead ESU. These programs propagate steelhead in 3 of 16 ESU populations and improve kelt (post-spawned steelhead) survival in 1 population. There are no artificial programs producing the winter-run life history in the Klickitat River and Fifteenmile Creek populations. All of the ESU hatchery programs are designed to produce fish for harvest, although two are also implemented to augment the naturally spawning populations in the basins where the fish are released. During the Status Review, NMFS' assessment of the effects of artificial propagation on ESU extinction risk concluded that these hatchery programs collectively do not substantially reduce the extinction risk of the ESU in total (NMFS 2004c). ESU hatchery programs may provide a slight benefit to ESU abundance. Artificial propagation increases total ESU abundance, principally in the Umatilla and Deschutes Rivers. The kelt reconditioning efforts in the Yakima River do not augment natural abundance but do benefit the survival of the natural populations.

The Touchet River Hatchery program has only recently been established, and its contribution to ESU viability is uncertain. The contribution of ESU hatchery programs to the productivity of the three target populations and the ESU in total is uncertain. The hatchery programs affect a small proportion of the ESU, providing a negligible contribution to ESU spatial structure. Overall, the impacts to ESU diversity are neutral. Collectively, artificial propagation programs in the ESU provide a slight beneficial effect to ESU abundance but have neutral or uncertain effects on ESU productivity, spatial structure, and diversity.

4.3.8.4 Recent Dam Counts and Returns to the Spawning Grounds

In their preliminary report, Fisher and Hinrichsen (2004) estimated a geometric mean of natural-origin MCR steelhead equal to 17,553 during 2001-2002, compared to 7,228 in 1996-2000, a 143% increase. The slope of the population trend for natural-origin fish increased 6.2% (from 0.99 to 1.05) when the data for 2001-2002 were added to the 1990-2000 series, reversing the decline and indicating that, at least in the short run, the natural-origin population has been increasing.

4.3.9 UWR Steelhead

4.3.9.1 ESU Structure

The UWR steelhead ESU includes all naturally spawned populations of winter-run steelhead in the Willamette River in Oregon and its tributaries upstream from Willamette Falls to the Calapooia River (inclusive) (64 FR 14517; March 25, 1999). The W/LC TRT (McElhany et al. 2004) identified four extant, demographically independent populations in one major population group (Appendix B, Figure B.9). NMFS' June 14, 2004, listing proposal did not resolve the ESU membership of native resident populations that are above recent (usually manmade) impassable barriers but below natural barriers. It was provisionally proposed that these resident populations not be considered part of the revised UWR steelhead ESU, until such time as significant scientific information becomes available to afford a case-by-case evaluation of their ESU relationships.

This ESU does not include any artificially propagated steelhead stocks that reside within the historical geographic range of the ESU. Hatchery summer steelhead occur in the Willamette Basin but are an out-of-basin stock that is not included in the ESU.

4.3.9.2 The BRT Findings

The BRT considered the cessation of the "early" winter-run hatchery program a positive sign for ESU diversity risk but remained concerned that releases of non-native summer steelhead continue. Because coastal cutthroat trout are dominant in the basin, resident steelhead are not as abundant or widespread here as in the inland proposed steelhead ESUs. The BRT did not consider resident fish to reduce risks to ESU abundance, and their contribution to ESU productivity, spatial structure, and diversity is uncertain (NMFS 2003, 2004b). The BRT found moderate risks for each of the VSP categories.

4.3.9.3 2004 Status Review

In its Status Review, NMFS noted that approximately one-third of the LCR steelhead ESU's historically accessible spawning habitat is now blocked. Notwithstanding the lost spawning habitat, the ESU continues to be spatially well distributed, occupying each of the four major subbasins (the Molalla, North Santiam, South Santiam, and Calapooia Rivers). There was some uncertainty about the historical occurrence of steelhead in drainages of the Oregon Coastal Range. Coastal cutthroat trout is a dominant species in the Willamette Basin, and thus steelhead are not expected to have been as widespread in this ESU as they are east of the Cascade Mountains.

4.3.9.4 Recent Dam Counts and Returns to the Spawning Grounds

In their preliminary report, Fisher and Hinrichsen (2004) estimated a geometric mean of natural origin UWR steelhead at Willamette Falls equal to 9,541 during 2001-2004, compared to 3,961 in 1996-2000, a 141% increase. The slope of the population trend increased 10.4% (from 0.93 to 1.02) when the data for

2001-2004 were added to the 1990-2000 series, reversing the decline and indicating that, at least in the short run, the natural-origin population has been increasing.

4.3.10 LCR Steelhead

4.3.10.1 ESU Structure

The LCR steelhead ESU includes all naturally spawned populations of steelhead in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington (inclusive) and the Willamette and Hood Rivers in Oregon (inclusive). Excluded are steelhead in the Upper Willamette River Basin above Willamette Falls and steelhead from the Little and Big White Salmon Rivers in Washington (62 FR 43937; August 18, 1997). The W/LC TRT (McElhany et al. 2004) identified a total of 20 extant, demographically independent populations in four major populations groups: Cascade winter-run, Cascade summer-run, Gorge winter-run, and Gorge summer-run in this ESU (Appendix B, Figure B.10).

NMFS' June 14, 2004, listing proposal did not resolve the ESU membership of native resident populations that are above recent (usually manmade) impassable barriers but below natural barriers. It was provisionally proposed that these resident populations not be considered part of the revised LCR steelhead ESU until such time as significant scientific information becomes available to afford a case-by-case evaluation of their ESU relationships. The presence of four major population groups in this ESU makes it is less likely that any single group is significant for this ESU's survival and recovery, compared to ESUs with fewer major population groups.

4.3.10.2 The BRT Findings

Approximately 35% of historical habitat has been lost in this ESU due to the construction of dams or other impassible barriers, but the ESU exhibits a broad spatial distribution in a variety of watersheds and habitat types. The BRT was particularly concerned about the impact on ESU diversity of the high proportion of hatchery-origin spawners in the ESU, the disproportionate declines in the summer steelhead life history, and the release of nonnative hatchery summer steelhead in the Cowlitz, Toutle, Sandy, Lewis, Elochoman, Kalama, Wind, and Clackamas Rivers. Resident fish are not as abundant in this ESU as they are in the proposed steelhead ESUs. The BRT did not consider resident fish to reduce risks to ESU abundance, and their contribution to ESU productivity, spatial structure, and diversity is uncertain (NMFS 2003, 2004b).

The BRT found moderate risks in each of the VSP categories.

4.3.10.3 2004 Status Review

In its Status Review, NMFS noted that some anadromous populations in the LCR steelhead ESU, particularly summer-run steelhead populations, had shown encouraging increases in abundance in the 2 to 3 years ending 2001. However, population abundance levels remained small (no population had a recent 5-year mean abundance greater than 750 spawners).

There are 10 artificial propagation programs releasing hatchery steelhead that are considered to be part of the LCR steelhead ESU. All of these programs are designed to produce fish for harvest, but several are also implemented to augment the natural spawning populations in the basins where the fish are released. Four of these programs are part of research activities to determine the effects of artificial propagation programs that use naturally produced steelhead for broodstock in an attempt to minimize the genetic effects of returning hatchery adults that spawn naturally. One of these programs, the Cowlitz River late-run winter steelhead program, is also producing fish for release into the Upper Cowlitz River Basin in an attempt to reestablish a natural spawning population above Cowlitz Falls Dam.

NMFS concluded that these hatchery programs collectively do not substantially reduce the extinction risk of the ESU in total (NMFS 2004c). The hatchery programs have reduced risks to ESU abundance by

increasing total ESU abundance and the abundance of fish spawning naturally in the ESU. The contribution of ESU hatchery programs to the productivity of the ESU in total is uncertain. It is also uncertain if steelhead reintroduced into the Upper Cowlitz River will be viable in the foreseeable future, because outmigrant survival appears to be quite low. As noted by the BRT, out-of-ESU hatchery programs have negatively impacted ESU productivity. The within-ESU hatchery programs provide a slight decrease in risks to ESU spatial structure, principally through the re-introduction of steelhead into the Upper Cowlitz River Basin. The eventual success of these reintroduction efforts, however, is uncertain. Collectively, artificial propagation programs in the ESU provide a slight beneficial effect on ESU abundance, spatial structure, and diversity but uncertain effects on ESU productivity.

4.3.10.4 Recent Dam Counts and Returns to the Spawning Grounds

In their preliminary report, Fisher and Hinrichsen (2004) estimated that the aggregate abundance of LCR steelhead was equal to 4,429 during 2001, compared to 6,333 during the period 1996- 2000, a 30% decrease in abundance. The slope of the aggregate population trend declined by 0.8% (from 0.93 to 0.92) when the 2001 count was added to the 1990-2000 data series.

4.3.11 CR Chum Salmon

4.3.11.1 ESU Structure

The W/LC TRT (McElhany et al. 2004) identified a total of 8 extant, demographically independent populations in three major population groups in this ESU: Coastal, Cascade, and Gorge (Appendix B, Figure B.11). Approximately 90% of the historical populations in the Columbia River chum ESU are extirpated or nearly so, and the Gorge population group was established by inferring that the approximately 100 adult chum salmon that ascend the Bonneville Dam fish ladders each year are spawning upstream. However, the Washington Department of Fish and Wildlife (WDFW) found only one and two carcasses in its 2002 and 2003 spawning ground surveys in the Gorge area, respectively, and its radio-tag data indicate that at least some fish fall back downstream (Ehlke and Keller 2003). The Smolt Monitoring Program has no record of juvenile chum salmon at Bonneville Dam.

4.3.11.2 The BRT Findings

The loss of off-channel habitats and the extirpation of approximately 17 historical populations increase the ESU's vulnerability to environmental variability and catastrophic events. The populations that remain are low in abundance and have limited distribution and poor connectivity. The BRT found high risks for each of the VSP categories, particularly for the ESU's spatial structure and diversity.

4.3.11.3 2004 Status Review

In its Status Review, NMFS noted that approximately 90% of the historical populations in the CR chum salmon ESU are extirpated or nearly so. During the 1980s and 1990s, the combined abundance of natural spawners for the Lower and Upper Columbia River Gorge, Washougal, and Grays River populations was below 4,000 adults. In 2002, however, the abundance of natural spawners exhibited a substantial increase at several locations. The preliminary estimate of natural spawners in 2002 was approximately 20,000 adults. The cause of this dramatic increase in abundance is unknown. Improved ocean conditions, the initiation of a supplementation program the Grays River, improved flow management at Bonneville Dam, favorable freshwater conditions, and increased survey sampling effort may have contributed to the elevated 2002 abundance. However, long- and short-term productivity trends for ESU populations were at or below replacement. The loss of off-channel habitats and the extirpation of approximately 17 historical populations increase the ESU's vulnerability to environmental variability and catastrophic events. The populations that remain are low in abundance, have limited distribution and poor connectivity.

There are three artificial propagation programs producing chum salmon considered to be part of the Columbia River chum salmon ESU. These are conservation programs designed to support natural productivity. The Washougal Hatchery artificial propagation program provides artificially propagated

chum salmon for reintroduction into recently restored habitat in Duncan Creek, Washington. This program also provides a safety net for the naturally spawning population in the mainstem Columbia River below Bonneville Dam. That population can access only a portion of spawning habitat during low-flow conditions. The other two programs are designed to augment natural production in the Grays River and the Chinook River in Washington. All these programs use naturally produced adults for broodstock. These programs were only recently established (1998-2002), with the first hatchery chum salmon returning in 2002.

NMFS' assessment of the effects of artificial propagation on ESU extinction risk concluded that these hatchery programs collectively do not substantially reduce the extinction risk of the ESU in total (NMFS 2004c). They have only recently been initiated and are just beginning to provide benefits to ESU abundance. The contribution of ESU hatchery programs to the productivity of the ESU in total is uncertain. The Sea Resources and Washougal Hatchery programs have begun to provide benefits to ESU spatial structure through reintroductions of chum salmon into restored habitats in the Chinook River and Duncan Creek, respectively. These three programs have a neutral effect on ESU diversity. Collectively, artificial propagation programs in the ESU provide a slight beneficial effect to ESU abundance and spatial structure but have neutral or uncertain effects on ESU productivity and diversity.

4.3.11.4 Recent Returns to the Spawning Grounds

In their preliminary report, Fisher and Hinrichsen (2004) estimated a geometric mean of the aggregate number of CR chum salmon in two index areas (Grays River and Hamilton and Hardy Creeks) equal to 1,776 during 2001-2003, compared to 2,114 in 1996-2000, a 16% decrease. The slope of the aggregate population trend decreased 1.5% (from 1.02 to 1.00) when the data for 2001-2003 were added to the 1990-2000 series.

4.3.12 SR Sockeye Salmon

4.3.12.1 ESU Structure

Anadromous sockeye salmon were once abundant in a variety of lakes throughout the Snake River Basin, including the Alturas, Pettit, Redfish, Stanley, and Yellowbelly Lakes in the Sawtooth Valley and in Wallowa, Payette, and Warm Lakes (Appendix B, Figure B.12), but the only remaining population resides in Redfish Lake. Beginning in the late nineteenth century, anadromous sockeye salmon were affected by heavy harvest pressures, unscreened irrigation diversions, and dam construction (TRT 2003). In addition, in the 1950s and 1960s, the Idaho Department of Fish and Game (IDFG) actively eradicated sockeye salmon from some locations. The SR sockeye salmon ESU includes populations of anadromous sockeye salmon from the Snake River Basin in Idaho, though extant populations occur only in the Stanley Basin (56 FR 58619; November 20, 1991). The ESU also includes residual sockeye salmon in Idaho's Redfish Lake, as well as one captive propagation hatchery program. Artificially propagated sockeye salmon from the Redfish Lake Captive Broodstock Program are considered part of this ESU. NMFS has determined that this artificially propagated stock is genetically no more than moderately divergent from the natural population (NMFS 2004c). Subsequent to the 1991 listing determination for SR sockeye salmon, a "residual" form of Snake River sockeye salmon (hereinafter residuals) was identified. The residuals often occur together with anadromous sockeye salmon and exhibit similar behavior in the timing and location of spawning. Residuals are thought to be the progeny of anadromous sockeye salmon but are generally non-anadromous. In 1993, NMFS determined that the residual population of Snake River sockeye salmon that exists in Redfish Lake is substantially reproductively isolated from kokanee (i.e., non-anadromous populations of *O. nerka* that become resident in lake environments over long periods of time), represents an important component in the evolutionary legacy of the biological species, and thus merits inclusion in the SR sockeye salmon ESU.

Only 16 naturally produced adults have returned to Redfish Lake since the Snake River sockeye salmon ESU was listed as an endangered species in 1991. All 16 fish were taken into the Redfish Lake Captive

Broodstock Program, which was initiated as an emergency measure in 1991. The return of over 250 adults in 2000 was encouraging; however, subsequent returns from the captive program in 2001 and 2002 have been fewer than 30 fish. The BRT found extremely high risks for all four VSP categories.

4.3.12.2 The BRT Findings and the 2004 Status Review

There is a single artificial propagation program producing SR sockeye salmon in the Snake River Basin. The Redfish Lake sockeye salmon stock was originally founded by collecting the entire anadromous adult return of 16 fish between 1990 and 1997, the collection of a small number of residual sockeye salmon, and the collection of a few hundred smolts migrating from Redfish Lake. These fish were put into a Captive Broodstock program as an emergency measure to prevent extinction of this ESU. Since 1997, nearly 400 hatchery-origin anadromous sockeye salmon adults have returned to the Stanley Basin from juveniles released by the program. Redfish Lake sockeye salmon have also been reintroduced into Alturas and Pettit Lakes using progeny from the captive broodstock program. The captive broodstock program presently consists of several hundred fish of different year classes maintained at facilities in Eagle, Idaho, and Manchester, Washington.

NMFS' assessment of the effects of artificial propagation on ESU extinction risk concluded that the Redfish Lake Captive Broodstock Program does not substantially reduce the extinction risk of the ESU in total (NMFS 2004c). The Artificial Propagation Evaluation Workshop noted that the Redfish Lake Captive Broodstock Program has likely prevented extinction of the ESU. This program has increased the total number of anadromous adults, attempted to increase the number of lakes in which sockeye salmon are present in the Upper Salmon River (Stanley Basin), and preserved what genetic diversity remains in the ESU. Although the program has increased the number of anadromous adults in some years, it has yet to produce consistent returns, and the long-term effects of captive rearing are unknown. The consideration of artificial propagation does not substantially mitigate the BRT's assessment of extreme risks to ESU abundance, productivity, spatial structure, and diversity.

4.3.12.3 Recent Dam Counts and Returns to the Spawning Grounds

In their preliminary report, Fisher and Hinrichsen (2004) estimated a geometric mean of aggregate numbers of SR sockeye salmon equal to 14 during 2001-2004 compared to 4 in 1996- 2000, a 211% increase. However, because returns were higher in 2001 and 2002 than in 2003, the slope of the aggregate population trend decreased 3.7% (from 1.26 to 1.22) when the data for 2001-2004 were added to the 1990-2000 series.

4.3.13 LCR Coho Salmon

4.3.13.1 ESU Structure

The W/LC TRT (McElhany et al. 2004) identified a total of 21 extant, demographically independent populations in three major population groups in this ESU: Coastal, Cascade, and Gorge (Appendix B, Figure B-13). There are only 2 extant populations in the LCR coho salmon ESU with appreciable natural productivity, the Clackamas and Sandy River populations, down from an estimated 23 historical populations in the ESU.

4.3.13.2 The BRT Findings

Short- and long-term trends in productivity are below replacement. Approximately 40% of historical habitat is currently inaccessible, which restricts the number of areas that might support natural productivity and further increases the ESU's vulnerability to environmental variability and catastrophic events. The extreme loss of naturally spawning populations, the low abundance of extant populations, diminished diversity, and fragmentation and isolation of the remaining naturally produced fish confer considerable risks on the ESU. The lack of naturally produced spawners in this ESU is contrasted by the very large number of hatchery-produced adults. The abundance of hatchery coho salmon returning to the Lower Columbia River in 2001 and 2002 exceeded 1 million and 600,000 fish, respectively. The BRT

expressed concern that the magnitude of hatchery production continues to pose significant genetic and ecological threats to the extant natural populations in the ESU. However, these hatchery stocks collectively represent a significant portion of the ESU's remaining genetic resources. The 21 hatchery stocks considered to be part of the ESU, if appropriately managed, may prove essential to the restoration of more widespread naturally spawning populations. The BRT found extremely high risks for all VSP categories.

4.3.13.3 2004 Status Review

There are only 2 extant populations in the LCR coho salmon ESU with appreciable natural production (the Clackamas and Sandy River populations), from an estimated 23 historical populations in the ESU. Although adult returns in 2000 and 2001 for the Clackamas and Sandy River populations exhibited moderate increases, the recent 5-year mean of natural-origin spawners for both populations represented less than 1,500 adults. The Sandy River population had exhibited recruitment failure in 5 of 10 years (i.e., 1992-2001), and had exhibited a poor response to reductions in harvest. During the 1980s and 1990s, natural spawners were not observed in lower basin tributaries. Coincident with the 2000–2001 abundance increases in the Sandy and Clackamas populations, a small number of coho salmon spawners of unknown origin have been surveyed in some of these areas. Short- and long-term trends in productivity are below replacement.

Approximately 40% of historical habitat is currently inaccessible, which restricts the number of areas that might support natural production, and further increases the ESU's vulnerability to environmental variability and catastrophic events. The extreme loss of naturally spawning populations, the low abundance of extant populations, diminished diversity, fragmentation, and isolation of the remaining naturally produced fish confer considerable risks. The paucity of natural-origin spawners is contrasted by the very large number of hatchery-produced adults. The numbers of hatchery coho salmon returning to the lower Columbia River in 2001 and 2002 exceeded 1 million and 600,000 fish, respectively.

All of the 21 hatchery programs included in the LCR coho salmon ESU are designed to produce fish for harvest, and 2 of the smaller programs are also designed to augment the natural spawning populations in the Lewis River Basin. Artificial propagation in this ESU continues to represent a threat to the genetic, ecological, and behavioral diversity of the ESU. Past artificial propagation efforts imported out-of-ESU fish for broodstock, generally did not mark hatchery fish, mixed broodstocks derived from different local populations, and transplanted stocks among basins throughout the ESU. The result is that the hatchery stocks considered to be part of the ESU represent a homogenization of populations. Several of these risks have recently begun to be addressed by improvements in hatchery practices. Out-of-ESU broodstock is no longer used, and near 100% marking of hatchery fish is employed to improve monitoring and evaluation of broodstock and (hatchery- and natural-origin) returns. However, many of the within-ESU hatchery programs do not adhere to best hatchery practices. Eggs are often transferred among basins in an effort to meet individual program goals, further compromising ESU spatial structure and diversity. Programs may use broodstock that does not reflect what was historically present in a given basin, limiting the potential for artificial propagation to establish locally adapted naturally spawning populations. Many programs lack Hatchery and Genetic Management Plans (HGMPs) that establish escapement goals appropriate for the natural capacity of each basin and that identify goals for the incorporation of natural-origin fish into the broodstock.

During the Status Review, NMFS' assessment of the effects of artificial propagation on ESU extinction risk concluded that hatchery programs collectively mitigate the immediacy of extinction risk for the LCR coho salmon ESU in total in the short-term, but these programs do not substantially reduce the extinction risk of the ESU in the foreseeable future (NMFS 2004c). At present, within-ESU hatchery programs significantly increase the abundance of the ESU in total. Without adequate long-term monitoring, the contribution of ESU hatchery programs to the productivity of the ESU in total is uncertain. The hatchery

programs are widely distributed throughout the Lower Columbia River, reducing the spatial distribution of risk from catastrophic events.

Additionally, reintroduction programs in the Upper Cowlitz River may provide additional reduction of ESU spatial structure risks. As mentioned above, the majority of the ESU's genetic diversity exists in the hatchery programs. Although these programs have the potential of preserving historical local adaptation and behavioral and ecological diversity, the manner in which these potential genetic resources are presently being managed poses significant risks to the diversity of the ESU in total. At present, the LCR coho salmon hatchery programs reduce risks to ESU abundance and spatial structure, provide uncertain benefits to ESU productivity, and pose risks to ESU diversity. Overall, artificial propagation mitigates the immediacy of ESU extinction risk in the short-term but is of uncertain contribution in the long-term.

Over the long-term, reliance on the continued operation of these hatchery programs is risky (NMFS 2004c). Several LCR coho salmon hatchery programs have been terminated, and there is the prospect of additional closures in the future. With each hatchery closure, any potential benefits to ESU abundance and spatial structure are reduced. Risks of operational failure, disease, and environmental catastrophes further complicate assessments of hatchery contributions over the long-term. Additionally, the two extant naturally spawning populations in the ESU were described by the BRT as being "in danger of extinction." Accordingly, it is likely that the LCR coho salmon ESU may exist in hatcheries only within the foreseeable future. It is uncertain whether these isolated hatchery programs can persist without the incorporation of natural-origin fish into the broodstock. Although there are examples of salmonid hatchery programs having been in operation for relatively long periods of time, these programs have not existed in complete isolation. Long-lived hatchery programs historically required infusions of wild fish in order to meet broodstock goals. The long-term sustainability of such isolated hatchery programs is unknown. It is uncertain whether the LCR coho salmon isolated hatchery programs are capable of mitigating risks to ESU abundance and productivity into the foreseeable future. In isolation, these programs may also become more than moderately diverged from the evolutionary legacy of the ESU and hence no longer merit inclusion in the ESU. Under either circumstance, the ability of artificial propagation to buffer the immediacy of extinction risk over the long-term is uncertain.

4.3.13.4 Recent Dam Counts and Returns to the Spawning Grounds

In their preliminary report, Fisher and Hinrichsen (2004) estimated a geometric mean of aggregate numbers of LCR coho salmon equal to 3,027 during 2001-2003, compared to 822 in 1996-2000, a 268% increase. The slope of the aggregate population trend increased 10.4% (from 0.92 to 1.02) when the data for 2001-2003 were added to the 1990-2000 series, reversing the decline and indicating that, at least in the short run, the aggregate run is increasing.

5.3 Factors Affecting Salmon and Steelhead Survival in the Action Area

An array of factors influences salmon and steelhead survival in the action area. These factors include dam and reservoir passage conditions at the eight FCRPS mainstem dams, hydrologic conditions, water quality conditions, predation, disease, artificial propagation programs, and harvest. The PA under consideration in this Opinion directly and indirectly affects hydrologic conditions in the action area. Changes in hydrologic conditions can affect dam and reservoir passage survival, water quality conditions (primarily water temperature), and disease and predation rates (by its influence on water temperature).

5.3.1 Baseline Physical Habitat Conditions in the Action Area

The Columbia River is a dynamic system. It has been affected and shaped over eons by a variety of natural forces, including volcanic activity, storms, floods, natural events, and climate changes. These forces had, and continue to have, a significant influence on biological factors, habitat, inhabitants, and the whole riverine and estuarine environment of the Columbia River. The Snake River and lower Columbia River and estuary habitats have been affected over the past 60 years by the existence and operation of the

series of mainstem hydropower dams and reservoirs (Section 5.2.1), as well as by the operation of both Federal and non-Federal upstream multipurpose storage projects. The impoundments have also inundated extensive salmon spawning and rearing habitat. Historically, fall chinook salmon spawned in mainstem reaches from near The Dalles, Oregon, upstream to the Pend Oreille and Kootenai Rivers in Idaho, and to

Table 5-1 Federal storage and diversion facilities and associated actions to develop a "Without Projects Operations" scenario.[1] Source: USBR 2004.

Storage Facility	Action
Jackson Lake Dam	Removed
Grassy lake Dam	Removed
Island Park Dam	Removed
American falls Dam	Removed
Minidoka Dam	Removed
Palisades Dam	Removed
Ririe Dam	Removed
Little Wood River Dam	Removed
Owyhee Dam	Removed
Anderson Ranch Dam	Removed
Arrowrock Dam	Removed
Lucky Peak Dam	Removed
Deadwood Dam	Removed
Cascade Dam	Removed
Hubbard Dam	Not modeled
Deer Flats Dam	Removed

Diversion Facility	Action
Cascade Creek Diversion Dam	Not modeled
Minidoka Northside Headworks	Diverts 40% of natural flow right
Minidoka Southside Headworks	Diverts 40% of natural flow right
Unit A Pumping Plant	Removed
Milner-Gooding Canal Headworks	Removed
falls Irrigation Pumping Plant	Removed
Tunnel No. 1	Removed
Dead Ox Pumping Plant	Removed
Ontario-Nyssa Pumping Plant	Removed
Gem Pumping Plants #1 and #2	Diverts private natural flow only
Boise River Diversion Dam	Diverts private natural flow only
Black Canyon Diversion Dam	Diverts private natural flow only

1 Project facilities and operations associated with the Vale, Mann Creek, Burnt River, and Baker Projects were not included in the Upper Snake River MODSIM model and therefore are not modeled in the "Without Projects Operations" simulation. Storage facilities associated with these projects include Warm Springs, Agency Valley, Bully Creek, Mann Creek, Unity, Mason, and Thief Valley Dams. Diversion facilities associated with these projects include Harper Diversion Dam, Bully Creek Diversion Dam, Mann Creek Dam Outlet, and Savely Dam and Lilley Pumping Plant.

the Snake River downstream of Shoshone Falls. Presently, mainstem production areas for fall chinook salmon are confined to the Hanford Reach of the Columbia River, the Hells Canyon Reach of the Snake River, the mid-Columbia River, and in the tailrace areas downstream from the lower Snake River projects and Bonneville Dam. The Hanford Reach is the only known mainstem spawning area for steelhead. Spawning habitat used historically by LCR Chinook salmon, CR chum salmon, and LCR steelhead was probably inundated by the Bonneville pool. Mainstem habitats in the lower Columbia and Willamette Rivers have been greatly reduced. What once were complex channels with bars, islands, and intricate flow patterns have often been reduced to a single thread. Floodplains have been reduced, off-channel habitat features have been eliminated or disconnected from the main channel, and the amounts of large woody debris in the channels have been greatly reduced. Finally, most of the remaining habitats are affected by flow fluctuations associated with reservoir water management for power peaking, flood control, irrigation, and other operations.

Estuarine habitat has been lost or altered directly through diking, filling, and dredging. Estuarine habitat has also been removed indirectly through changes to flow regulation that affect sediment transport and salinity within specific habitats in the estuary. Not only have rearing habitats been removed, but the habitats needed to support tidal and seasonal movements of juvenile salmon are no longer accessible because connections have been lost.

Major changes in the estuary resulting from anthropogenic alterations include a loss of vegetated, shallow-water habitat and changes in the size, seasonality, and behavior of the plume. These changes have significant consequences for salmonid diversity and population productivity. ESUs with fry and fingerling life-history strategies that use and depend upon these shallow-water habitat areas are most significantly affected by these changes (Fresh et al. 2004).

The lower Columbia River estuary lost about 43% of its historical tidal marsh (from 16,180 to 9,200 acres) and 77% of historical tidal swamp habitats (from 32,020 to 6,950 acres) between 1870 and 1970 (Thomas 1983). One example is the diking and filling of floodplains formerly connected to the tidal river

that have resulted in the loss of large expanses of low-energy, offchannel habitat for salmon rearing and migrating during high flows. Similarly, diking of estuarine marshes and forested wetlands within the estuary have removed most of these important off-channel habitats. Sherwood et al. (1990) estimated that the Columbia River estuary lost 20,000 acres of tidal swamps; 10,000 acres of tidal marshes; and 3,000 acres of tidal flats between 1870 and 1970.

The total volume of the estuary inside the entrance has declined by about 12% since 1868 (Sherwood et al. 1990). This study further estimated an 80% reduction in emergent vegetation production and a 15% decline in benthic algal production. The authors analyzed early navigational charts and noted profound bedform changes in the river entrance from year to year. The pre-development river mouth was characterized by shifting shoals, sandbars, and channels forming ebb and flood tide deltas. Prior to jetty construction, the navigable channel over the tidal delta varied from a single, relatively deep channel in some years to two or more shallow channels in other years.

Within the lower Columbia River, diking, river training devices (pile dikes and riprap), railroads, and highways have narrowed and confined the river to its present location. Between the Willamette River and the mouth of the Columbia River, diking, flow regulation, and other human activities have resulted in the confinement of 84,000 acres of floodplain that likely contained large amounts of aquatic habitat (i.e. tidal marsh, and swamp). The lower Columbia River's remaining tidal marsh and swamp habitats are located in a narrow band along the banks of the Columbia River and its tributaries and around undeveloped islands.

Since the late 1800s, the Corps has been responsible for maintaining navigation safety on the Columbia River. During that time, the Corps has taken many actions to improve and maintain the navigation channel. The channel has been dredged periodically to make it deeper and wider and annually for maintenance. To improve navigation and reduce the frequency of maintenance dredging, the navigation channel has also been realigned and hydraulic control structures, such as in-water fills, channel constrictions, and pile dikes, which act as break-waters, have been built. Most of the present day pile dike system was built in the periods 1917-1923 and 1933-1939, with an additional 35 pile dikes constructed between 1957 and 1967.

The existing navigation channel pile dike system consists of 256 pile dikes, totaling 240,000 linear feet. Ogden Beeman and Associates (1997) noted that navigation channel maintenance activities from 1885 to 1985 required closing of river side channels, realigning river banks, removing rock sills, stabilizing river banks, and placement of river "training" features. Most of these habitat alterations were constructed or occurred before the listings of any Pacific salmonids as endangered and threatened species.

These aforementioned physical changes also affect other factors in the riverine and estuarine environment. Tides raise and lower river levels at least 4 feet and up to 12 feet twice every day. The historical range for tides was probably similar, but seasonal ranges and extremes in water surface elevations have certainly changed because of river flow regulation and stream bank development. The salinity level in areas of the estuary can vary from zero to 34 parts per thousand (ppt), depending on tidal intrusion, river flows, and storms. The salinity wedge is believed to have ranged from the river mouth to as far upstream as RM 37.5 in the past. It is now generally believed that the upper edge of the wedge ranges between the mouth and RM 30. The river bed within the navigation channel is composed of a continuously moving series of sand waves that can migrate downstream up to 20 feet per day at flows of 400,000 cfs or greater and the lesser rates at lower flows.

As development has changed the circulation pattern in the estuary, it has increased shoaling rates such that the estuary is now a more effective sediment trap (Independent Science Group 1996). Although the Columbia River is characterized as a highly energetic system, it has been changing as a result of

development and is now similar to more developed and less energetic estuaries throughout the world (Sherwood et al. 1990).

In addition, model studies indicate that the hydrosystem and climate change together have decreased suspended particulate matter to the lower river and estuary by about 40% (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50% or more (Bottom et al. 2001). Overbank flow events, important to habitat diversity, have become rare, in part because water storage and irrigation withdrawals prevent high flows, and in part because diking and revetments have increased the "bank full" flow level (from about 18,000 to 24,000 m^3/s). The dynamics of estuarine habitat have changed in other ways relative to flow and stream bank development. The availability of shallow (between 10 cm and 2 m depth), low-velocity (less than 30 cm/s) habitat now appears to decrease at a steeper rate with increasing flow than during the 1880s, and the absorption capacity of the estuary appears to have declined.

The significance of these changes for salmonids is unclear. Estuarine habitat is likely to have provided services (food and refuge from predators) to subyearling migrants that resided in estuaries for up to two months or more (Casillas 1999). Historical data from Rich (1920) indicate that small juvenile salmon (< 50 mm), which entered the Columbia River estuary during May, grew 50 mm to 100 mm during June, July, and August. Data from a more contemporary period (Dawley et al. 1986; CREDDP 1980) show neither small juveniles entering the estuary in May nor growth over the summer season.

The Columbia River plume also appears to be an important habitat for juvenile salmonids, particularly during the first month or two of ocean residence. The plume may simply represent an extension of the estuarine habitat. More likely, it represents a unique habitat created by interaction of the Columbia River freshwater flow with the California current and local oceanographic conditions. Ongoing studies show that nutrient concentrations in the plume are similar to nutrient concentrations associated with upwelled waters. Upwelling is a well recognized oceanographic process that produces highly productive areas for fish. Primary productivity, and more important, the abundance of zooplankton prey, is higher in the plume compared with adjacent non-plume waters. Further, salmon appear to prefer low surface salinity, as the abundance and distribution of juvenile salmon are higher and more concentrated in the Columbia River plume than in adjacent, more saline waters. These findings support the notion that the plume is an important habitat for juvenile salmonids. What is not known precisely is how Columbia River flows affect the structure of the plume relative to salmonid biological requirements during outmigration periods, and whether critical threshold flows are needed.

5.3.2 Hydrologic Conditions

Hydrologic conditions influence salmonid survival through the migratory corridor by changing the rate of migration; affecting water quality, particularly water temperature, turbidity, and TDG concentrations; and by influencing FCRPS project operations.

Flow regulation, water withdrawal, and climate change have reduced the Columbia River's average flow and altered its seasonality, sediment discharge and turbidity, thereby changing the estuarine ecosystem (National Research Council 1996; Sherwood et al. 1990; Simenstad et al. 1982, 1990; Weitkamp 1994). Annual spring freshet flows through the Columbia River estuary are about one-half of the traditional levels that flushed the estuary and carried smolts to sea, and total sediment discharge is about one-third of nineteenth-century levels. For instance, reservoir storage and flow regulation that began in the 1970s has reduced the 2-year flood peak discharge, as measured at The Dalles, Oregon, from 580,000 cfs to 360,000 cfs (Corps 1999).

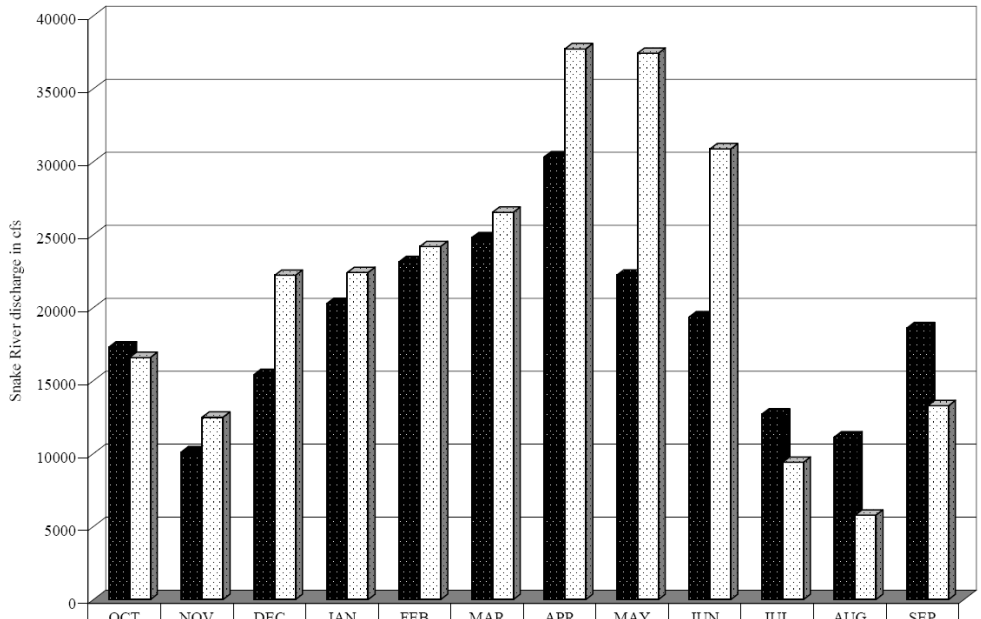
Decreased spring flows and sediment discharges have also reduced the extent, speed of movement, thickness, and turbidity of the plume that extended far out and south into the Pacific Ocean during the spring and summer (Cudaback and Jay 1996; Hickey et al. 1997). Changes in estuarine bathymetry and

flow have altered the extent and pattern of salinity intrusion up the Columbia River and have increased stratification and reduced mixing (Sherwood et al. 1990). The direct effects of flow on juvenile survival are the relationships between flow and travel time and flow and the distribution of fish among the various dam passage routes. In general, the lower the flow through the series of FCRPS reservoirs, the longer the travel time of outmigrating juveniles. The longer juveniles remain in project reservoirs, the greater their exposure to predation, disease, and other mortality factors. Also, the longer juveniles remain in the project reservoirs, the greater the potential that they will residualize (remain in fresh water for months to another year). Changing flows can also affect dam operations as operating protocols are often defined in terms of streamflow criteria. For example, at spring flows of less than 85,000 cfs at Lower Granite Dam, the spill rate and duration are reduced. Spillways are widely considered the safest route of juvenile dam passage (Ferguson et al. 2004). Changing flows indirectly affect juvenile survival by changing water temperatures. Lower flows result in higher summer water temperatures (all other conditions being equal). High summer water temperatures increase disease, predation rates, and thermal stress on juvenile salmonids.

Very high flow conditions can cause high rates of involuntary spill at FCRPS projects in the migratory corridor. High spill rates can generate supersaturated TDG concentrations in downstream waters. This effect is discussed in Section 5.3.3, Water Quality Conditions. Streamflows are directly affected by the PA and these effects and their associated effects on salmon survival are the focus of the analysis of effects generated in developing this Opinion (Section 6).

Agricultural water use in the Snake and Columbia Basins began around 1850 and accelerated rapidly in the early twentieth century (Volkman 1997). Today, about 85% of water consumption in the basins is associated with irrigated agriculture. For example, at Brownlee Reservoir, all upstream water use reduces flows by about 6 million acre-feet (Maf) annually, about one-third of native flows (USBR 1999). At Lower Granite Dam, upstream water developments consume about 6.4 Maf, about 7% of native flows. At McNary Dam, upstream water uses consume about 12 Maf annually, about 12% of native flows. At Bonneville Dam, about 13.3 Maf is consumed at upstream water developments. This water consumption reduces streamflows primarily during the growing season (April through October), has affected the status of the species in the action area, and is included in the environmental baseline (reference operation). Future water consumption is discussed in Section 7.2, Cumulative Effects.

The principal change in environmental conditions between those currently existing and those under the reference operation (current conditions absent the effects of the USBR's upper Snake project operations) is the change in Snake and Columbia River flows. Because all project facilities are located upstream from Brownlee Reservoir, Idaho, this change is best illustrated by estimated inflows to Brownlee Reservoir (Figure 5-2). This depiction of Snake River flow conditions is intended to illustrate how the baseline hydrology used in this Opinion differs from the existing conditions.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current Flows	17294	10122	15416	20273	23136	24787	30333	22230	19366	12708	11138	18610
Reference Operation	16584	12504	22217	22417	24186	26534	37731	37440	30876	9413	5780	13286

Figure 5-2. Mean monthly Snake River inflow (cfs) at Brownlee Dam under current conditions and under the reference operation. Sources: current conditions, BPA HYDSIM model run

5.3.3 Water Quality Conditions

Water and sediment quality is another important aspect of the environmental condition of the lower Columbia River ecosystem with the potential to affect salmonids' growth and survival. Water quality in streams throughout the Columbia River Basin has been degraded by human activities such as dams and diversion structures, water withdrawals, farming and grazing, road construction, timber harvest activities, mining activities, and urbanization. Over 2,500 streams and river segments and lakes do not meet Federally approved, State, and tribal water quality standards and are now listed as water quality-limited under Section 303(d) of the Clean Water Act (CWA). Tributary water quality problems contribute to poor water quality where sediment and contaminants from the tributaries settle in mainstem reaches and the estuary.

The importance of three water quality characteristics—water temperature, TDG concentrations, and water and sediment pollutants—are discussed below.

5.3.3.1 Water Temperature

Salmonids evolved to take advantage of the natural cold, freshwater environments of the Pacific Northwest. Temperature directly governs their metabolic rate and directly influences their life history. Natural or anthropogenic fluctuations in water temperature can induce a wide array of behavioral and physiological responses in these fish. Feeding, growth, resistance to disease, successful reproduction, sufficient activity for competition and predator avoidance, and successful migrations are all affected by water temperatures (Yearsley 1999). These behavioral and physiological effects may lead to impaired functioning of the individual and decreases viability at the organism, population, and species level.

Williams (2004) noted that multivariate models indicated that the condition that had the strongest effect on survival of yearling chinook salmon through the Snake River was water temperature. For yearling chinook salmon, temperatures above 13°C appeared detrimental to survival. The date on which

temperatures at Lower Monumental Dam reached 13°C varied from year to year, ranging from May 7 in 1998 to June 11 in 1997. The average date on which this apparent threshold temperature was reached was May 25 (Williams et al 2004). Zaugg and Wagner (1973) found that gill Na + -K + ATPase (an indicator of migratory readiness) and migratory urge declined at water temperatures of 13°C and higher. Steelhead that migrate too late in the season, when water temperatures are above this threshold, may have a tendency to residualize. For subyearling chinook salmon, Williams et al (2004) noted that average survival was nearly constant for water temperature below 19.3°C, and nearly constant, but considerably lower for water temperature above 20.6°C.

For Snake River fall chinook salmon juveniles, Connor et al (2003) determined that flow and temperature explained 92% of the observed variability in cohort survival from points of release in Hells Canyon to the tailrace of Lower Granite Dam and built a multiple regression model of cohort survival based on these parameters. Cohort survival generally increased as flow increased, and decreased as temperature increased (Connor 2003). Based on the regression model developed, survival is predicted to change by approximately 3% with each change of 100 m^3/s in flow when temperature is held constant. The change in survival is approximately 7% for each 1°C change in temperature when flow is held constant (Connor 2003).

The Snake River from its confluence with the Salmon River at RM 188 to its confluence with the Columbia River has been included on the 303(d) list (a list of impaired waters compiled under Section 303(d) of the CWA) for water temperature by Idaho, Oregon, and Washington. Additionally, Oregon and Washington include most of the mainstem Columbia River on their lists as impaired for temperature. Most of the water bodies in Oregon, Washington, and Idaho that are on the 303(d) list are included because they do not meet water quality standards for temperature. Water temperature alterations affect salmonid metabolism, growth rate, and disease resistance, as well as the timing of adult migrations, fry emergence, and smoltification (EPA 2002). Many factors can cause high stream temperatures, but they are primarily related to land- and water-use practices rather than point-source discharges (Coutant 1999).

Water temperatures in excess of the States of Washington and Oregon's 20°C (68°F) water quality standards (e.g., OAR, Ch. 30, Division 041) stress anadromous salmonids and can directly or indirectly cause mortality (e.g., increase fish susceptibility to disease, increase predation rates of piscivorous fish). Some common actions that have resulted in high stream temperatures are the removal of trees or shrubs that directly shade streams, excessive water withdrawals for irrigation or other purposes, and warm irrigation return flows. Loss of wetlands and increases in groundwater withdrawals have contributed to lower base-stream flows, which in turn contribute to temperature increases. Water temperature is also directly affected by streamflow conditions through the effects of changes in the mass affected by heat flux. For this Opinion, NMFS has employed both Environmental Protection Agency (EPA) and Corps water temperature modeling. Under the reference operation, EPA (2005) estimated water temperature conditions in the Snake and Columbia Rivers throughout the peak juvenile migration season (April through September) for low, average, and high water years (Table 5-2).

Table 5-2. Estimated water temperatures (in °C) at selected FCRPS dams for low, average, and high flow years under the reference operation. Source: EPA 2005.

	Lower Granite Dam			Ice Harbor Dam			McNary Dam		
	Low 2000	Ave 1995	High 1997	Low 2000	Ave 1995	High 1997	Low 2000	Ave 1995	High 1997
April	9.7	8.4	8.3	9.8	8.3	8.4	8.7	8.1	7.9
May	12.5	11.5	10.9	13.2	11.9	11.4	12.2	11.9	11.6
June	15.5	14.5	14.1	15.9	14.6	14.5	15.3	15.1	14.8
July	18.7	18.7	19.5	21.0	20.0	19.9	20.0	19.5	18.6
August	20.2	19.2	19.6	22.7	21.5	23.0	21.6	20.0	21.5
September	19.0	19.6	18.4	20.9	20.6	20.1	19.7	18.3	19.2

In some instances, these modeling results appear to be counterintuitive. For example, at Lower Granite Dam under the high water conditions of 1997, a lower July water temperature than the average or dry years would be expected, all other conditions being equal. However, the Snake River upstream from Lower Granite Dam is a warmer river than the Clearwater River, the other major Snake River tributary entering Lower Granite Reservoir. Therefore, higher flows in the Snake River can result in warmer water temperatures at Lower Granite Dam. The Corps attempts to control water temperatures at Lower Granite Dam by releasing cold water (7°C) from Dworshak Dam on the Clearwater River at rates up to 14 kcfs. When flows are warm and high coming out of the Snake River Basin, this measure would have a lesser effect on water temperatures at Lower Granite Dam.

5.3.3.2. Total Dissolved Gas

High rates of spill at mainstem FCRPS dams can cause high TDG concentrations. High TDG concentrations can cause gas bubble trauma (GBT) in adult and juvenile salmonids resulting in injury or death. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains below 1% when TDG concentrations in the upper water column do not exceed the Oregon and Washington water quality standard (110%) and gas waiver levels of 120% in FCRPS project tailraces and 115% in forebays. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT. Exceedence of this standard is generally associated with high rates of involuntary spill associated with the peak of the annual runoff hydrograph. Current reservoir operations typically limit gas-generating, high-spill events to a few days or weeks during high-flow years. Historically, TDG supersaturation was considered a major contributor to juvenile salmon mortality, and TDG control has been a focus of efforts to improve salmon survival. The Corps has invested heavily in controlling TDG at its projects in the migratory corridor through the installation of spillway improvements and by managing spill operations to reduce gas entrainment, and thorough TDG monitoring and abatement evaluation.

As part of the TDG abatement program, the Corps has developed spill limits at its projects designed to prevent the creation of adverse TDG conditions downstream. For example, the spill cap at Lower Granite Dam in the 2004 Water Management Plan (Corps 2004) is 43,000 cfs. Using the 50-year simulated hydrology for the environmental baseline (reference operation), the spill cap at Lower Granite Dam would be exceeded on a monthly average basis as follows: March, 1 out of 50; April, 2 out of 50; May, 12 out of 50; and June, 14 out of 50.

5.3.3.3 Pollutants

Background or ambient levels of pollutants in inflows carry cumulative loads from upstream areas in variable and generally unknown amounts. Municipal and industrial waste discharges have occurred in the greater Lewiston, Idaho-Clarkston, Washington area and have been received from larger population centers in the Upper Snake River Basin. Major tributaries and drainages have delivered higher background concentrations of metals, which are generally associated with mining areas that are common in portions of the Clearwater and Salmon Rivers and in tributaries throughout the Upper Snake River.

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 (PAH) (NWFSC Environmental Conservation Division 2001). These data indicate that juvenile salmonids within the Columbia River estuary have contaminant body burdens that may already be within the range where sublethal effects may occur, although the sources of exposure could be widespread and are not clear. In field studies, juvenile salmon from sites in the Pacific Northwest have demonstrated immunosuppression, reduced disease resistance, and reduced growth rates due to contaminant exposure during their period of estuarine residence (Arkoosh et al. 1991, 1994, 1998; Varanasi et al. 1993; Casillas et al. 1995a, 1995b, 1998a).

5.3.4 Predation

Salmon and steelhead are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Ocean predation may also contribute to significant natural mortality, although the levels of predation are largely unknown. In general, salmonids are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the rebound of seal and sea lion populations, following their protection under the Marine Mammal Protection Act of 1972, has resulted in substantial mortality for salmonids. In recent years, for example, sea lions have learned to target UWR spring chinook salmon in the fish ladder at Willamette Falls and other spring Chinook salmon ESUs in the tailrace area downstream from Bonneville Dam.

Dams and reservoirs are generally believed to have increased the incidence of predation over historical levels (Poe et al. 1994). Effects such as the increase in habitat suitable for predatory fish, warmer near-surface water temperatures that increase their foraging rates, and the delay and aggregation of migrating salmonids in project forebays and tailraces all increase the susceptibility of anadromous fish to predation (NMFS 2004a, Section 5.3.1).

5.3.5 Disease

Columbia Basin salmonids co-exist with a range of viruses, bacteria, fungi, and parasites. Some of these organisms have significant effects on salmon populations through mortality or reduced fitness (morbidity). These organisms are collectively known as pathogens. For salmonid and pathogen populations to persist, interactions between host and pathogen, like interactions between predator and prey, must maintain a dynamic balance where neither party is wholly eliminated. Three major factors in this balance have been identified as host, environment, and pathogen. A change in one or more of these three factors will result in a change in the equilibrium, often resulting in large outbreaks of disease (epizootics) which may decimate salmonid populations (Hedrick 1998; Gerstman 2003; Arkoosh et al. 2004).

With the development of the Columbia Basin, a number of factors emerged which have the potential to cause shifts in the host-pathogen equilibria, increasing risks of epizootics. Dams and other impoundments increased summer water temperatures, creating conditions where some pathogens increased their infectivity (rate of spread) and virulence (severity of effects on the host organism), while at the same time stressing salmonids and reducing their resistance to disease (Becker and Fujihara 1978; WDOE 2002; Mesa et al. 2000). The introduction of exotic species and the between-basin transfer of native fishes creates opportunities for the introduction of new pathogens, or for endemic pathogens to increase their range. Large-scale intensive hatchery culture provides conditions where pathogens could spread rapidly within the hatchery, and increases the risk of transfer of disease out of the hatchery through hatchery effluents and the release of infected fish. Changing environmental conditions altered relationships between parasites and their hosts, potentially increasing the severity of parasitic infection. Handling and transport of fish at dams has led to fish being held at much higher densities than observed in the wild, increasing chances of disease transmission. Thus, with changes in host, pathogen, and environment, a shift in host-pathogen relationships from pre-development conditions has occurred.

The effects of disease on wild salmonid populations are notoriously hard to enumerate, and the significance of a particular pathogen may also widely vary among different salmonid populations (Hedrick 1998). Diseases which have been observed to cause significant losses to migrating fish (both hatchery and wild) in the Columbia River system are Columnaris (*Flexibacter columnaris*) (Becker and Fujihara 1978), bacterial kidney disease (*Renibacterium salmoninarum*) (Arkoosh et al. 2004; Elliot et al. 1997), and ceratomyxosis (*Ceratomyxa shasta*) (Ratliff 1981; Bartholomew 1998). With the interruptions of natural disease control mechanisms through shifts in environmental conditions, introductions of new pathogens (or changes in distribution of endemic ones), or introduction of new potential sources of pathogens, such as hatcheries, this equilibrium has been substantially altered and the potential for large epizootics and high losses to salmonid populations has increased.

Effects of Temperature on Disease. In addition to the stress and direct physiological damage suffered by salmonids when exposed to elevated water temperatures, risks of mortality due to disease also increase. There appear to be two primary reasons for this increase. Temperature related stress reduces the capacity of the fish to resist infection and eliminate pathogens.

Pathogens also respond to changes in temperature. There is a particular range of optimum temperatures for each pathogen and in this range the reproduction, infectivity, and virulence of a pathogen are maximized. The combination of reduced resistance of fish and increased virulence and infectivity of a particular pathogen can result in epizootics and high rates of mortality due to disease. In a summary of issues related to temperature criteria for salmon, the EPA (2001) summarized the effects of water temperature on disease risk as follows:

Risk Temperature range (°C)
Minimized <12-13°
Elevated 14-17°
Severe 18-20°

There are a number of pathogens known in the Columbia Basin which show a direct increase in infectivity and virulence with increased water temperature. Some diseases, such as Columnaris (*Flexibacter columnaris*), are rare within the natural range of water temperatures in the Columbia Basin (i.e., temperatures that would be observed absent man-caused effects) (Becker and Fujihara 1978). A brief summary of Columbia Basin pathogens with the potential for causing increased mortality among salmonids under elevated water temperature conditions is described in Table 5-3.

Table 5-3. Fish diseases known from the Columbia Basin showing increases in infectivity and virulence with increasing water temperature (WDOE 2002; EPA 1999; EPA 2001)

Organism	Disease	Temperature effects	Susceptible species	Severity of effects
Bacteria				
Flexibacter columnaris	Columnaris	epizootics strongly related to high water temperature (>15	All species	Has been observed to cause high levels of mortality among wild and hatchery populations, ^{o} C)
Renibacterium salmoninarum	Bacterial Kidney Disease (BKD)	Increased temperatures reduce infectivity, but increase the severity of infections (time until death) in laboratory trials.	All salmonids, especially chinook and sockeye	Often causes high levels of mortality in hatcheries. High prevalence in some wild fish populations.
Aeromonas salmonicida	Furunculosis	Epizootics strongly correlated with temperature	All fishes	Has been observed to cause high levels of mortality in the wild and hatcheries
Myxobacter sp.	Bacterial Gill Disease (BGD)	Epizootics strongly correlated with water temperature and poor water quality	All fishes	
Parasites				
Ceratomyxa Shasta	Ceratomyxosis	Increased temperatures reduced time from exposure to death in laboratory studies.	Salmonids, especially chinook	Has been observe to cause high levels of mortality in the wild and in hatcheries.
Icthyopthirius multifilis	Ich	Epizootics strongly associated with temps >15 ^{o} C	All fishes	Has been observed to cause high levels of mortality in the wild and in hatcheries

Organism Disease Temperature effects Susceptible species
Severity of effects Bacteria
Juvenile salmon and steelhead mortalities from an array of disease have been observed at many fish collection and handling systems in the migratory corridor. Columnaris and BKD are two common diseases observed at mainstem FCRPS juvenile fish collection facilities. In many cases, the proximate causes of fish mortality in the action area are largely unknown. While it is known that juvenile passage survival is lower under low-flow, high-temperature conditions, it is seldom known whether the direct cause of death is thermal stress, increased predation, or increased susceptibility to disease, or a combination of these factors.

5.3.6 Artificial Propagation
Artificial propagation programs mandated by Congress under the Lower Snake River Compensation Program are included in the environmental baseline for this consultation. Many artificial propagation facilities under this program were originally authorized to help mitigate for the construction of the four Federal lower Snake River hydroelectric dams. Other Federally funded artificial propagation programs in the Snake Basin are not included in the environmental baseline for this consultation, as they are currently undergoing consultation.

Although located outside of the action area, all Federal and non-Federal artificial propagation programs in the Columbia Basin above Priest Rapids Dam are also part of the environmental baseline for this consultation. They are included because hatchery progeny pass through the lower Columbia River migration corridor and interact with ESA-listed fish that are the focus of this consultation. The current Section 7 biological opinion for hatchery operations associated with unlisted salmon species (for Federally funded programs) and Permit 1347 (for Stateoperated programs) both expire October 22, 2013. ESA permits (1396, USFWS and 1412, Confederated Tribes of the Colville Reservation) associated with listed steelhead are in place through October 2, 2008, and permit 1395 (issued to WDFW) is in place through October 2, 2013. ESA permit 1300 issued to the USFWS to propagate listed spring chinook salmon is in place through December 31, 2007, and permit 1196 issued to WDFW expires January 20, 2014. Artificial propagation programs in the Columbia Basin below the confluence with the Snake River are not included in the environmental baseline for this consultation. New ESA authorization is in process for these programs.

Because hatcheries have traditionally focused on providing fish for harvest, it is only recently that the substantial adverse effects of hatcheries on natural populations have been demonstrated. For example, hatchery practices, among other factors, have contributed to the 90% reduction in natural coho salmon runs in the lower Columbia River over the past 30 years (Flagg et al. 1995). NMFS has identified four primary ways hatcheries harm natural-origin salmon and steelhead: 1) ecological effects, 2) genetic effects, 3) overharvest effects, and 4) masking effects.

Ecologically, hatchery-origin fish can prey on, displace, and compete with natural fish. These effects are most likely to occur when hatchery-reared juveniles are released in poor condition and remain in the fresh water for extended rearing periods rather than migrating to marine waters. Hatchery-origin fish also can transmit hatchery-borne diseases, and hatcheries themselves can release disease-carrying effluent into streams. Hatchery-origin fish can affect the genetic variability of native fish by interbreeding with them. Outbreeding depression can result from the introduction of stocks from other areas. Genetic interactions like these can result in fish being less adapted to the local habitats where the original native stock evolved, and may therefore be less productive there.

In many areas, hatchery-origin fish provide increased fishing opportunities. However, when natural fish mix with hatchery-origin fish in these areas, naturally produced fish can be overharvested. Moreover, when migrating adult hatchery and natural fish mix on the spawning grounds, the health of the natural runs and the habitat's ability to support them can be overestimated because hatchery fish can mask the actual natural run status from surveyors' observations.

The role hatcheries play in the Columbia Basin is being redefined by NMFS' proposed hatcherylisting policy, developing environmental impact statements, and recovery planning efforts. These efforts will focus on maintaining and improving ESU viability. Research designed to clarify interactions between natural and hatchery fish and quantify the effects of artificial propagation on natural fish will play a pivotal role in informing these efforts. The final facet of these initiatives is to use hatcheries to create fishing opportunities that are benign to listed populations (e.g., terminal area fisheries).

5.3.7 Harvest

Treaty Indian Harvest. Treaty Indian fishing rights are included in the environmental baseline for this consultation. The four Columbia River "Stevens" Treaty Tribes (the Nez Perce, Umatilla, and Warm Springs Tribes, and the Yakama Indian Nation) entered into treaties with the United States in 1855. In exchange for the Indians relinquishing their interest in certain lands, the treaties reserved to the Tribes "exclusive" on-reservation rights and the right to take "fish at all usual and accustomed places in common with citizens of the United States" outside the reservations on the Columbia River and major tributaries.

Indian treaty rights, such as hunting and fishing rights, are reserved rights that generally date from time immemorial. See Felix S. Cohen, *Handbook of Federal Indian Law*, 441-448 (1982); *United States v. Winans*, 198 U.S. 371, 381 (1905), 25 S.Ct. 662, 49 L.Ed. 1089 ("In other words, the treaty was not a grant of rights to the Indians, but a grant of right from them -- a reservation of those not granted. There was an exclusive right of fishing reserved within certain boundaries. There was a right outside of those boundaries reserved 'in common with the citizens of the territories"). Starting in 1977, Tribal and State fisheries subject to U.S. v. Oregon have been regulated pursuant to a series of Court orders reflecting Court-approved settlement agreements among the parties. The last long-term agreement, known as the Columbia River Fishery Management Plan (CRFMP), was adopted and approved by the Court in 1988 and expired in 1999. At the Court's direction and under its supervision, the parties are currently in the process of negotiating a new long-term agreement.

During the past 10 years, harvest has been managed pursuant to the CRFMP and successor agreements that contain restraints on the fisheries necessitated by the ESA listings of some of the ESUs. As a result, NMFS has conducted ESA Section 7 consultations and issued no-jeopardy opinions covering these agreements and their impact on ESA-listed species.

Agreed-to and estimated harvest rates for various stocks under the current U.S. v. Oregon agreements are set forth in Tables 5-4 and 5-5. For the purpose of projecting the environmental baseline into the future, these current harvest rates are assumed to continue through the term of this Opinion. In terms of the analysis in the Opinion, it does not matter whether the Tribes harvest all of the harvest available to them or, as has been the practice, allocate a portion of that harvest to the States. Accordingly, to estimate the extent of this baseline harvest, NMFS will presume that treaty and non-treaty harvest rates comparable to the current harvest rates will continue into the future pursuant to Court-approved settlement agreements. In addition, the Colville Confederated Tribal fisheries have been consulted on and remain in effect through October 2012.

Non-Indian Harvest. Non-Indian fisheries include both commercial and sport fishing harvest and mortality. Commercial harvest of listed ESUs occurs as an unintentional bycatch during fisheries aimed at hatchery fish. Intentional sport fishing harvest of listed fish is limited to populations considered healthy. Most hatchery progeny in the basin are marked by the removal of their adipose fins and anglers are required to release unmarked fish in most fisheries to protect listed stocks. However, a small fraction of the unmarked fish caught and released by sport fishermen suffer injury or stress and subsequently die. Estimates of total non-Indian harvests are shown in Tables 5-4 and 5-4 and are considered part of the environmental baseline for this consultation.

Table 5-4. Expected harvest rates for listed salmonids in winter, spring, and summer season fisheries in the mainstem Columbia River and in tributary recreational fisheries under the 2001 - 2005 Spring Agreement in U.S. v. Oregon NA—similar estimates not available for other areas. (Table modified from NMFS 2004b)

ESU	Non-Indian Fisheries		Treaty Indian Fisheries
	Mainstem	Tributary Fisheries	Mainstem
Snake River fall chinook	0	0	0
Snake River spring/summer chinook	<0.5-2.0%[a]	NA	5.0-15.0%[a]
Upper Columbia River spring chinook	<0.5-2.0%[a]	NA	5.0-15.0%[a]
Lower Columbia River chinook	2.7%[b]	NA	0
Upper Willamette River chinook	<15%[d]	-[d]	0
Snake River steelhead			
A-run	0.2%	2.5%[e]	2.7%[f]
B-run	0	2.5%[e]	0[f]
Upper Columbia River steelhead			
Naturally-produced	0.6%	NA	3.8%
Hatchery-produced	4.5%	NA	2.7%
Mid-Columbia River steelhead	<2.0%[g]	NA	3.6%
Lower Columbia River steelhead	<2.0%[g]	NA	1.6%
Upper Willamette River steelhead	<2.0%[g]	<1.2%	0
Lower Columbia River coho	0	0	0
Columbia River chum	0	0[h]	0
Snake River sockeye	<1.0%	0	<7.0%

[a] Allowable harvest rate varies depending on run size.
[b] Spring component of the Lower Columbia River ESU only.
[c] Impacts in tributary fisheries will be population specific depending on where the fisheries occur.
[d] Harvest rate limited to 15% or less in all non-Indian mainstem and tributary fisheries.
[e] Maximum harvest rate applied to wild fish passing through terminal fishery areas where hatchery fish are being targeted; hooking mortality of 5% applied to an assumed 50% encounter rate. Harvest rates to stocks not passing through targeted terminal fishing areas will be less.
[f] B-run steelhead of the current return year are primarily caught in fall season fisheries. However, a portion of the summer steelhead run holds over in the Lower Columbia River above Bonneville dam until the following winter and spring; these fish, thought to be mostly A-run, are caught in fisheries in those seasons.
[g] Harvest rate limits for winter-run populations.
[h] Chum may be taken occasionally in tributary fisheries below Bonneville Dam. Retention is prohibited.

5.3.8 Population Response to Environmental Variation

The abundance of salmonid populations is substantially affected by changes in the freshwater and marine environments that are in turn the result of large-scale environmental variations. For example, large-scale climatic regimes, such as El Niño, affect changes in ocean productivity. Much of the Pacific Coast was subject to a series of very dry years during the first part of the 1990s and since 2000. In the latter 1990s, severe flooding adversely affected some stocks. For example, the low return of Lewis River bright fall chinook salmon in 1999 is attributed to flood events during 1995 and 1996.

Among the known variations in ocean conditions are the phenomena termed El Niño and the Pacific Decadal Oscillation (PDO).

Table 5-5. Expected harvest rates for listed salmonids in fall season fisheries in the mainstem Columbia River under the 2004 Fall Agreement in U.S. v. Oregon. (Table modified from NMFS 2004b).

ESU	Non-Indian Fisheries	Treaty Indian Fisheries
Snake River fall chinook	8.25%	23.04%
Snake River spring/sum chinook	0	0
Upper Columbia River spring chinook	0	0
Lower Columbia River chinook		
Spring component	0%	0%
Tule component	12.4%	0%
Bright component	11.8%	0%
Upper Willamette River chinook	0	0
Snake River steelhead		
A-run	≤2% (1.1%)[a]	3.4%
B-run	≤2% (1.7%)[a]	15% (13.6%)[a]
Upper Columbia River steelhead		
Natural-origin	≤2% (1.1%)[a]	3.4%
Hatchery-origin	10.9%	5.7%
Mid-Columbia River steelhead	≤2% (1.1%)[a]	3.4%
Lower Columbia River steelhead	≤2% (0.3%)[a]	0.1%
Upper Willamette River steelhead	0	0
Lower Columbia River coho	6.4%	0
Columbia River chum	5% (1.6%)[a]	0%
Snake River sockeye	[b]	[b]

[a]Maximum proposed harvest rates with the expected harvest rates associated with the proposed fisheries shown in parenthesis.

[b]8% cap (combined Tribal and non-Tribal harvest)

El Niño is a disruption of the ocean-atmosphere system in the tropical Pacific having important consequences for global weather patterns and near-shore Pacific Ocean productivity (http://www.pmel.noaa.gov/tao/elnino/gif/summer_winter1-nns.gif). Among these consequences are warmer near-surface ocean water temperatures along the U.S. west coast, and generally warmer, drier weather in the Pacific Northwest. This warmer surface layer reduces thermodynamic upwelling off the U.S. coast, reducing nutrient inputs to the euphotic zone, which reduces near-shore ocean productivity. This reduction in productivity has been shown to reduce juvenile salmon growth and survival (Mantua and Francis in press). Warmer surface waters can also change the spatial distribution of marine fishes with potential predator-prey effects on salmon. The warmer, drier weather in the Pacific Northwest often associated with El Niño can also cause or increase the severity of regional droughts. Droughts reduce streamflows through the Columbia and Snake River migratory corridor, increase water temperatures, and reduce the extent of suitable habitat in some drainages. Each of these physical effects has been shown to adversely affect salmon survival. Thus, El Niño events can present a substantial drag on anadromous fish populations.

The PDO is a long-lived El Niño-like pattern of Pacific climate variability. While the two climate oscillations have similar spatial climate fingerprints, they have very different behavior in time. Fisheries scientist Steven Hare coined the term "Pacific Decadal Oscillation" (PDO) in 1996 while researching connections between Alaska salmon production cycles and Pacific climate. Two main characteristics distinguish the PDO from El Niño. First, 20th century PDO "events" persisted for 20 to 30 years, while

typical El Niño events persisted for 6 to 18 months. Second, the climatic fingerprints of the PDO are most visible in the North Pacific/North American sector, while secondary signatures exist in the tropics. The opposite is true for El Niño. Several independent studies find evidence for just two full PDO cycles in the past century. "Cool" PDO regimes prevailed from 1890-1924 and again from 1947-1976, while "warm" PDO regimes dominated from 1925-1946 and from 1977 through (at least) the mid- 1990s. Shoshiro Minobe has shown that twentieth century PDO fluctuations were most energetic in two general periodicities, one from 15 to 25 years, and the other from 50 to 70 years. (Quoted from: http://tao.atmos.washington.edu/pdo/.) Major changes in northeast Pacific marine ecosystems have been correlated with phase changes in the PDO. Warm eras have seen enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the contiguous United States, while cold PDO eras have seen the opposite north-south pattern of marine ecosystem productivity. Causes for the PDO are not currently known. Likewise, the potential predictability for this climate oscillation is not known. Some climate simulation models produce PDO-like oscillations, although often for different reasons. Discovery of the mechanisms giving rise to PDO will determine whether skillful, decades-long PDO climate predictions are possible. For example, if PDO arises from air-sea interactions that require 10-year ocean adjustment times, then aspects of the phenomenon will (in theory) be predictable at lead times of up to 10 years. Even in the absence of a long-term predictive understanding, PDO climate information improves season-to-season and year-to-year climate forecasts for North America because of its strong tendency for multi-season and multi-year persistence. From a societal impacts perspective, recognition of PDO is important, because it shows that "normal" climate conditions can vary over time periods comparable to the length of a human's lifetime.

Recent evidence suggests that marine survival of salmonids fluctuates in response to the PDO's 20- to 30-year cycles of climatic conditions and ocean productivity (Cramer et al. 1999). Ocean conditions that affect the productivity of Northwest salmonid populations appear to have been in a low phase of the cycle for some time and an important contributor to the decline of many stocks. The survival and recovery of these species will depend on their ability to persist through periods of low natural ocean survival, but the mechanism whereby stocks are affected is not well understood. The pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. NMFS presumes that juvenile fish survival is driven largely by events occurring between ocean entry and recruitment to a subadult life stage. One indicator of early ocean survival can be computed as a ratio of coded-wire-tag (CWT) recoveries of subadults relative to the number of CWTs released from that brood year. Time series of survival rate information for UWR spring chinook salmon, Lewis River fall chinook salmon, and Skagit fall chinook salmon show highly variable or declining trends in early ocean survival, with very low survival rates in recent years (NMFS 1999b).

5.3.9 Dam and Reservoir Passage

As stated above, the eight Federal dams on the mainstem Columbia and lower Snake Rivers that dominate the characteristics of fish habitat in the migratory corridor in the action area from the upstream limit of Lower Granite Reservoir on the Snake River to Bonneville Dam on the Columbia River, are part of the environmental baseline. A substantial amount of juvenile mortality occurs in this reach and delay in passing the dams can affect adult survival and may affect fecundity.

The effects of changes in flow due to the operation and maintenance of the USBR's Upper Snake Basin projects on dam and reservoir passage survival through the mainstem Columbia and lower Snake River FCRPS projects are a focus of the analysis conducted for this Opinion. The 2004 FCRPS UPA included an array of measures to improve dam passage survival. Those improvements that have already occurred or are expected to occur within the next year (by spring 2006) are included in the near-term environmental baseline analysis. The effects of those system configuration improvements are expected to continue until the long-term FCRPS configuration improvements are implemented fully by 2014. FCRPS fish passage facility improvements and operations beyond 2014 are undefined but, for the purposes of this

consultation, are assumed to result in survival rates that are the same or higher than those estimated in the long-term (2014) analysis in the 2004 FCRPS Biological Opinion (NMFS 2004a). Thus, for the purposes of this consultation, the long-term effects of all of those FCRPS configuration improvements are assumed to remain about the same as those estimated in the long-term (2014) analysis and are expected to continue throughout the term of this biological opinion as part of the long-term environmental baseline.

5.3.9.1 Passage Effects on Juvenile Salmon and Steelhead Survival

Juvenile salmon dam and reservoir passage survival has been the subject of extensive research and evaluation and has dominated efforts taken to improve survival of the species through numerous ESA Section 7 consultations.

NMFS placed the first Pacific Northwest salmon ESU on the Endangered Species list in 1991. Since then, NMFS and the FCRPS Action Agencies have engaged in numerous consultations. The focus of those consultations has been on the survival of listed juvenile salmon and steelhead as they migrate through the FCRPS and measures to improve it. Biological opinions outlining a number of proposed operations and structural configuration changes to FCRPS dams designed to improve juvenile survival were issued in 1993, 1994, 1995, 1998, 2000, and 2004. Measures taken to improve juvenile salmon survival through the FCRPS migratory corridor include: water management to increase spring and summer migration season flows, juvenile collection systems and transportation programs, voluntary spills at FCRPS dams, improved spillway juvenile passage efficiency (e.g., removable spillway weirs [RSW]), predatory fish control, and other measures. As a result of these operations and configuration improvements, juvenile survival through the FCRPS migration corridor has improved significantly since the early 1990s. For Snake River spring/summer chinook salmon juveniles migrating in-river, Williams et al. (2004) estimated survival through the eight mainstem Federal dams is now between 28% and 58%, compared with an estimated survival rate during the 1970s of 3% to 30% (Williams et al. 2001). For Snake River steelhead juveniles migrating in-river, Williams et al. (2004) estimated survival through the eight mainstem Federal dams to currently range between 4% and 50%, compared with an estimated survival rate during the 1970s of 1% to 27% (Williams et al. 2001). The transportation of smolts from the Snake River and McNary Dam on the Columbia River has also improved FCRPS system passage survival rates.

Although changes in FCRPS operations and configuration, including juvenile transportation around portions of the Federal hydrosystem, have improved juvenile passage survival, periods of warm weather and low runoff continue to cause high rates of mortality among out-migrants in Lower Granite Reservoir. Lower Granite is the uppermost FCRPS reservoir in the migratory corridor and juvenile fish must pass through this reach without the aid of transportation (i.e., the juvenile collection facilities are located downstream at Lower Granite Dam).

5.3.9.1.1 Methods Used to Estimate Juvenile Passage Survival Rates. [omitted]

5.3.9.2 Passage Effects on Adult Salmon and Steelhead

Adult salmon and steelhead must pass up to eight FCRPS dams and reservoirs in the action area to reach their natal spawning streams and river reaches. Each FCRPS project within the action area imposes stresses on migrating adults. Those project-induced effects most likely to adversely affect adult survival are delay and delay-induced predation, water quality changes (e.g., TDG concentrations and water temperatures), and fallback and volitional downstream passage (e.g., steelhead kelts).

Delay. To pass each mainstem FCRPS dam, adult fish must successfully locate and ascend the project fish ladder(s). The ability to successfully pass each dam has been found to be affected by project configuration and various operating characteristics, principally attraction flow rates, project spill patterns, and powerhouse discharge patterns. However, Bjornn et al. (2000) estimated that the median time to transit the lower Snake River in 1993 was the same or less with dams than it would be without dams,

suggesting that adult passage timing through the FCRPS dams and reservoirs is relatively unaffected by the FCRPS. This is due to the faster transit times through project reservoirs than would occur in a naturally flowing river combined with any dam passage delays.

Available data suggest that mainstem FCRPS projects with well designed and carefully operatedfishways result in very low mortality rates for migrating adults. High per-project and system survivals indicate adult salmonid biological requirements are generally being met during passage through the FCRPS under the environmental baseline.

Increasing pinniped predation of adult salmon and steelhead near the fishway entrances at Bonneville Dam is a concern for all ESUs that have populations upstream of Bonneville Dam. Efforts to evaluate and minimize this problem are part of the 2004 FCRPS UPA (Corps et al. 2004). As solution of this problem is uncertain, pinniped predation at Bonneville Dam's fishway entrances is part of the environmental baseline for this consultation.

Fallback and Volitional Downstream Passage. Fallback refers to adult fish that pass a dam and then are entrained in the spillway, navigation lock, or powerhouse intakes, and pass back through the dam. Fallback of adult spring/summer chinook salmon passing mainstem dams during spill has been found to reduce the number of fish that passed between tops of ladders at Bonneville Dam and Lower Granite or Priest Rapids Dams (after adjustments for harvest). Fallback of steelhead at Bonneville and Ice Harbor Dams similarly has been found to reduce escapement (Keefer and Peery 2004). During 1996-2002, escapement, on average, was lower for fallback fish by 6.5% for spring/summer chinook salmon ($P<0.05$), 19.5% for fall chinook salmon ($P<0.005$), and 13.2% for steelhead ($P<0.005$) (Keefer et al. 2004). Multiplying the percentage reduction in escapement for fish that fall-back by the percentage of fish that actually fallback provides an estimate of the reduction in overall system escapement (e.g., steelhead: 13.2% lower escapement for fallback fish * 21.4% fish that fell back = 2.82% reduction in escapement). Accordingly, average reductions in overall run escapements were estimated at 1.30% (range=0.46-2.27%), 2.26% (range=1.32-2.91%) and 2.82% (range = 1.34-4.02%) for spring/summer chinook salmon, fall chinook salmon, and steelhead, respectively as a result of dam passage.

However, system-wide adult passage information showed no significant difference in spring/summer chinook salmon and steelhead escapement due to fallback during spill (about 30- 50 kcfs) and no spill periods in 2001 (Keefer and Peery 2004). Escapements of adult steelhead from Bonneville to Lower Granite Dam adjusted for harvest in 2000, 2001, and 2002, were very similar (87.6, 85.2, and 85.6%, respectively), even though 2001 had very little spill at dams compared with 2000 and 2002. No differences ($P<0.05$) in escapement were found for fallback of spring/summer and fall chinook salmon with and without spill for all years (1996-2002) pooled (Keefer et al. 2004). These similar escapements with and without spill may be due to so few fish falling back during non-spill periods. Further, with all years combined, steelhead escapement was significantly higher ($P=0.002$) during no spill at John Day Dam, and marginally higher ($P=0.056$) during no spill at Bonneville Dam.

Steelhead Kelts. Only recently have studies been conducted to identify kelt (post-spawning, downstream-migrating adult steelhead) numbers and to investigate downstream passage success and route-specific passage at dams. Studies conducted since 2000 have shown that over 13,000 kelts passed John Day Dam, and 83% of the kelts observed at Lower Granite Dam were females. For fish tagged and released at Lower Granite Dam, 3.8%, 13.3%, and 34.4% were detected below Bonneville Dam in 2001, 2002, and 2003, respectively (Boggs and Peery 2004). Migration rates in 2003 were positively correlated with river flow ($P<0.0001$, $R_2 = 0.63$). Conditions that provided the 34% survival to below Bonneville Dam in 2003 include spill at dams and a very large freshet in late May/early June when kelts were migrating.

Repeat spawning rates for Snake River steelhead currently average less than 2% (Ferguson et al. 2004).

This is about the same repeat spawning rate observed by Whitt (1954) when returning fish only had to negotiate two dams compared to the current eight, suggesting that factors other than dam passage may have a more significant effect on kelt survival.

Sublethal Effects. Adult salmon exposed to suboptimal water quality conditions in the migratory corridor and/or delayed by FCRPS dams may succeed in reaching their spawning grounds yet exhibit poor spawning success due to sublethal dam passage experience. For example, stressed fish are known to produce smaller and fewer eggs than fish in excellent condition. Information is not currently available to determine whether such sublethal effects occur as a result of FCRPS dam passage or whether such effects are biologically significant.

5.3.10 Anticipated Changes in Environmental Baseline Conditions in the Action Area

Over the 30-year life of this Opinion, numerous changes in the action area environment are likely. For those anticipated future actions for which ESA Section 7 consultations have been completed, the nature and characteristics of anticipated changes in the action area environment are evaluated as part of the environmental baseline for this Opinion. Those actions anticipated to be completed or to show marked effects on the environmental baseline only after March 2006 are part of the long-term environmental baseline for this consultation and are described below. The Corps constructed riprap levees along the lower Snake and Clearwater Rivers and continues to regularly dredge sediment from channels in the upper part of Lower Granite Reservoir in order to maintain flood conveyance and navigation channels to ports in the Lewiston and Clarkston area. These actions were analyzed in NMFS' March 15, 2004, Biological Opinion, "Lower Snake and Clearwater Rivers 2004-2005 Dredging Snake River fall chinook salmon, Snake River spring/summer chinook salmon, and Snake River steelhead" (NMFS 2004d), and are part of the environmental baseline for this Opinion. Discharge from Potlatch Pulp and Paper Mill in Lewiston, Idaho, into the surface waters and sediments in the lower Clearwater and Snake Rivers is expected to increase levels of total suspended solids and elevate concentrations of some organic constituents. This action was analyzed in NMFS' April 2, 2004, Biological Opinion, "Potlatch Pulp and Paper Mill, Lewiston, Idaho, National Pollution Discharge Elimination System (NPDES) Permit No.: ID-000116-3 for the discharge of effluents into the Snake River, Nez Perce County, Idaho and Asotin County, WA (1 Project)" (NMFS 2004e).

The 2004 FCRPS UPA includes an array of actions that will be completed or show marked effect on the environment after March 2005 (Corps et al. 2004). As the various measures in the UPA are implemented; NMFS anticipates dam passage survival, particularly for juvenile fish, will continue to improve. The long-term environmental baseline analyzed for this Opinion includes all the configuration and operational changes and the increased predator control proposed in the 2004 FCRPS UPA (Corps et al. 2004).

Several actions in the 2004 FCRPS UPA are designed to improve the performance of fish protection systems (e.g. improved inspections, maintenance, and spare part inventories). Although these actions are expected to improve fish survival within the action area for this Opinion, their effects are implicitly included in our analysis in that our approach assumes that all fish protection systems are constantly functioning at their normal performance levels. Other 2004 FCRPS UPA actions that will provide greater system flexibility (e.g., reducing electrical transmission system constraints) are important to facilitating an adaptive management approach to fish protection, but the fish survival benefits are impossible to quantify at this time. Others are likely to improve fish survival outside the action area for this Opinion (e.g., tributary habitat enhancements).

5.3.10.1 Anticipated Operations and Configurations Improvements at FCRPS Dams That Will Improve Long-term Fish Survival in the Action Area

In their 2004 FCRPS UPA and subsequent Records of Decision, the Action Agencies committed to numerous fish passage facility improvements. In addition, individual dams will be operated as further

detailed in the water management plans, the implementation plans, the processes afforded through the Regional Forum, and the project decision documents. These measures include a number of actions that would measurably improve juvenile passage survival. NMFS modified SIMPAS parameters to simulate these long-term FCRPS operations and configuration improvements and estimated juvenile passage survival in the long-term environmental baseline (Table 5-7). Appendix A describes the anticipated system configuration and operation changes included in the long-term environmental baseline.

5.3.10.2 Expanded Predator Control

The FCRPS Action Agencies will expand efforts to reduce predation of juvenile salmon by birds and other fish. Caspian tern management actions are expected to be implemented as early as 2005 (pending completion of environmental review and approval), with resulting juvenile survival improvements as early as 2006. Increased incentives under the NPMP will also improve the survival of juveniles from all ESUs in the Columbia Basin. It is not currently possible to quantitatively estimate the long-term juvenile survival improvements for listed ESUs from these expanded predator control efforts.

Table 5-7. Estimated average juvenile survival rates through the FCRPS under the long-term reference operation. Estimated survivals in the free-flowing river (survival in the absence of the FCRPS dams) are presented for comparison. These estimates do not include possible post- Bonneville latent mortality of in-river migrants. Source: NMFS staff (Appendix A)

ESU	Estimated Juvenile In-river Survival Rate	Estimated Juvenile System Survival Rate (including transport latent effects)	Estimated Free-Flowing River Survival Rate[h]
SR Spring/Summer Chinook Salmon[a]	58.5% (49.1% to 64.9%)	53.5% (49.5% to 57.3%)	78.6%
SR Fall Chinook Salmon[a,g]	14.9% (3.4% to 24.5%) 6.2 in-river fish per 1000 @ LGR pool alive below BON (2.4-10.8)	N/A	50.8%
UCR Spring Chinook Salmon	73.4% (58.0% to 80.6%)	N/A	85.5%
LCR Chinook:			
Gorge Fall MPGs[b]	86.1% (81.9% to 97.3%)	N/A	95.5%
Gorge Spring MPGs[c]	90.9% (85.0% to 94.1%)	N/A	98.4%
Below BON Dam MPGs	N/A	N/A	N/A
UWR Chinook Salmon	N/A	N/A	N/A
SR Steelhead[a]	38.0% (9.0% to 50.8%)	50.5% (43.0% to 54.9%)	82.1%
UCR Steelhead	55.4% (24.3% to 69.8%)	N/A	87.9%
MCR Steelhead:[d]			
Passing MCN-BON	55.4% (24.3% to 69.8%)	N/A	88.9%
Passing JDA Pool-BON	62.5% (32.2% to 78.0%)	N/A	91.5%
From JDA Dam-BON	76.5% (45.8% to 93.0%)	N/A	95.6%
Passing TDA-BON	78.6% (47.0% to 95.5%)	N/A	96.4%
Passing BON Dam	87.2% (64.9% to 97.6%)	N/A	99.1%
LCR Steelhead:[e]			
Passing BON Dam	87.2% (64.9% to 97.6%)	N/A	99.1%
Below BON Dam	N/A	N/A	N/A
UWR Steelhead	N/A	N/A	N/A
CR Chum	N/A	N/A	N/A
SR Sockeye	N/A	N/A	N/A
LCR Coho[f]	90.9% (85.0% to 94.1%)	N/A	95.5%

[a] The estimated juvenile in-river survival rates shown in this table for transported ESUs are only for those fish that remain in-river for their entire juvenile migration and are not transported.

[b] Estimated juvenile survival rates for LCR (fall) chinook salmon are based on per-project survival rate of SR fall chinook salmon.

[c] Estimated juvenile survival rates for LCR (spring) chinook salmon are based on per-project survival rate of SR spring/summer chinook salmon.

[d] Estimated juvenile survival rates for MCR steelhead are based on per-project survival rate of SR steelhead.

[e] Estimated juvenile survival rates for LCR steelhead are based on per-project survival rate of SR steelhead.

[f] Estimated juvenile survival rates for LCR coho salmon are based on per-project survival rate of SR spring chinook salmon.