APPENDIX A
BIOLOGICAL REQUIREMENTS, CURRENT STATUS, AND TRENDS: TWELVE COLUMBIA RIVER BASIN EVOLUTIONARILY SIGNIFICANT UNITS

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A.1 OVERVIEW OF STATUS OF SPECIES AND CRITICAL HABITAT

Appendix A provides, for each of the 12 Columbia River Basin Evolutionarily Significant Units (ESUs), a description of the species, critical habitat designations, a general life history, and a detailed discussion of population dynamics and distribution. Table A-1 provides a summary of each salmon species listed and proposed for listing under the Endangered Species Act (ESA). Table A-2 provides a summary of critical habitat designations under ESA.

Table A-1. Summary of Salmon Species Listed and Proposed for Listing under the Endangered Species Act

Species	Evolutionarily Significant Unit	Present Status	Federal Register Notice	
Chinook Salmon	Sacramento River Winter	Endangered	59 FR 440	1/4/94
(*O. tshawytscha*)	Snake River Fall	Threatened	57 FR 14653	4/22/92
	Snake River Spring/Summer	Threatened	57 FR 14653	4/22/92
	Central Valley Spring	Threatened	64 FR 50393	9/16/99
	California Coastal	Threatened	64 FR 50393	9/16/99
	Puget Sound	Threatened	64 FR 14308	3/24/99
	Lower Columbia River	Threatened	64 FR 14308	3/24/99
	Upper Willamette River	Threatened	64 FR 14308	3/24/99
	Upper Columbia River Spring	Endangered	64 FR 14308	3/24/99
Chum Salmon	Hood Canal Summer-Run	Threatened	64 FR 14508	3/25/99
(*O. keta*)	Columbia River	Threatened	64 FR 14508	3/25/99
Coho Salmon	Central California Coastal	Threatened	61 FR 56138	10/31/96
(*O. kisutch*)	S. Oregon/ N. California Coastal	Threatened	62 FR 24588	5/6/97
	Oregon Coastal	Threatened	63 FR 42587	8/10/98
Sockeye Salmon	Snake River	Endangered	56 FR 58619	11/20/91
(*O. nerka*)	Ozette Lake	Threatened	64 FR 14528	3/25/99
Steelhead	Southern California	Endangered	62 FR 43937	8/18/97
(*O. mykiss*)	South-Central California	Threatened	62 FR 43937	8/18/97
	Central California Coast	Threatened	62 FR 43937	8/18/97
	Upper Columbia River	Endangered	62 FR 43937	8/18/97
	Snake River Basin	Threatened	62 FR 43937	8/18/97
	Lower Columbia River	Threatened	63 FR 13347	3/19/98
	California Central Valley	Threatened	63 FR 13347	3/19/98
	Upper Willamette River	Threatened	64 FR 14517	3/25/99
	Middle Columbia River	Threatened	64 FR 14517	3/25/99
Cutthroat Trout	Umpqua River	Endangered	61 FR 41514	8/9/96
Sea-Run	Southwest Washington/Columbia	Proposed Threatened	64 FR 16397	4/5/99
(*O. clarki clarki*)	River			

Table A- 2. Summary of Critical Habitat Designations under the Endangered Species Act

Species	Evolutionarily Significant Unit	Federal Register Notice	
Chinook Salmon	Sacramento River Winter	58 FR 33212	6/16/93
(*O. tshawytscha*)	Snake River Fall	58 FR 68543	12/28/93
	Snake River Spring/Summer	58 FR 68543	12/28/93
	Revised:	64 FR 57399	10/25/99
	Central Valley Spring	65 FR 7764	3/9/98
	California Coastal	65 FR 7764	3/9/98
	Puget Sound	65 FR 7764	2/16/00
	Lower Columbia River	65 FR 7764	2/16/00
	Upper Willamette River	65 FR 7764	2/16/00
	Upper Columbia River Spring	65 FR 7764	2/16/00
Chum Salmon	Hood Canal Summer-Run	65 FR 7764	2/16/00
(*O. keta*)	Columbia River	65 FR 7764	2/16/00
Coho Salmon	Central California Coastal	64 FR 24049	5/5/99
(*O. kisutch*)	S. Oregon/ N. California Coastal	64 FR 24049	5/5/99
	Oregon Coastal	65 FR 7764	2/16/00
Sockeye Salmon	Snake River	58 FR 68543	12/28/93
(*O. nerka*)	Ozette Lake	65 FR 7764	2/16/00
Steelhead	Southern California	65 FR 7764	2/16/00
(*O. mykiss*)	South-Central California	65 FR 7764	2/16/00
	Central California Coast	65 FR 7764	2/16/00
	Upper Columbia River	65 FR 7764	2/16/00
	Snake River Basin	65 FR 7764	2/16/00
	Lower Columbia River	65 FR 7764	2/16/00
	California Central Valley	65 FR 7764	2/16/00
	Upper Willamette River	65 FR 7764	2/16/00
	Middle Columbia River	65 FR 7764	2/16/00
Cutthroat Trout	Umpqua River	63 FR 1388	1/9/98
Sea-Run	Southwest Washington/Columbia River	none proposed	
(*O. clarki clarki*)			

A.2 SPECIES DESCRIPTIONS AND CRITICAL HABITAT DESIGNATIONS

A.2.1 Chinook Salmon

A.2.1.1 Snake River Spring/Summer Chinook Salmon

The Snake River (SR) spring/summer chinook salmon ESU, listed as threatened on April 22, 1992 (67 FR 14653), includes all natural-origin populations in the Tucannon, Grande Ronde, Imnaha, and Salmon rivers. Some or all of the fish returning to several of the hatchery programs are also listed including those returning to the Tucannon River, Imnaha, and Grande Ronde hatcheries, and to the Sawtooth, Pahsimeroi, and McCall hatcheries on the Salmon River. Critical habitat was designated for SR spring/summer chinook salmon on December 28, 1993 (58 FR 68543) and was revised on October 25, 1999 (64 FR 57399).

A.2.1.2 Snake River Fall Chinook Salmon

The SR fall chinook salmon ESU, listed as threatened on April 22, 1992 (67 FR 14653), includes all natural-origin populations of fall chinook in the mainstem Snake River and several tributaries including the Tucannon, Grande Ronde, Salmon, and Clearwater rivers. Fall chinook from the Lyons Ferry Hatchery are included in the ESU but are not listed. Critical habitat was designated for SR fall chinook salmon on December 28, 1993 (58 FR 68543).

A.2.1.3 Upper Columbia River Spring-Run Chinook Salmon

The Upper Columbia River (UCR) spring-run chinook salmon ESU, listed as endangered on March 24, 1999 (64 FR 14308), includes all natural-origin stream-type chinook salmon from river reaches above Rock Island Dam and downstream of Chief Joseph Dam, including the Wenatchee, Entiat, and Methow River basins. All chinook in the Okanogan River are apparently ocean-type and are considered part of the UCR Summer-and Fall-run ESU. The spring-run components of the following hatchery stocks are also listed: Chiwawa, Methow, Twisp, Chewuch, and White rivers, and Nason Creek. Critical habitat was designated for Upper Columbia River spring chinook salmon on December 28, 1993 (58 FR 68543).

A.2.1.4 Upper Willamette River Chinook Salmon

The Upper Willamette River (UWR) chinook salmon ESU, listed as threatened on March 24, 1999 (64 FR 14308), occupies the Willamette River and tributaries upstream of Willamette Falls, in addition to naturally produced spring-run fish in the Clackamas River. UWR spring chinook salmon are one of the most genetically distinct chinook groups in the Columbia River (CR) basin. Fall chinook salmon spawn in the upper Willamette but are not considered part of the ESU because they are not native. None of the hatchery populations in the Willamette River were listed although five spring-run hatchery stocks were included in the ESU. Critical habitat was designated for UWR chinook salmon on February 16, 2000 (58 FR 68543).

A.2.1.5 Lower Columbia River Chinook Salmon

The Lower Columbia River (LCR) chinook salmon ESU, listed as threatened on March 24, 1999 (64 FR 14308), includes all natural-origin populations of both spring- and fall-run chinook salmon in tributaries to the Columbia River from a transition point located east of the Hood River, Oregon, and the White Salmon River, Washington, to the mouth of the Columbia River at the Pacific Ocean and in the Willamette River below Willamette Falls, Oregon (excluding spring chinook salmon in the Clackamas River). Not included in this ESU are "stream-type" spring-run chinook salmon found in the Klickitat River (which are considered part of the Mid-Columbia River Spring-Run ESU) or the introduced Carson spring-chinook salmon strain. "Tule" fall chinook salmon in the Wind and Little White Salmon rivers are included in this ESU, but not introduced "upriver bright" fall-chinook salmon populations in the Wind, White Salmon, and Klickitat rivers. The Cowlitz, Kalama, Lewis, Washougal, and White Salmon rivers, constitute the major systems on the Washington side; the lower Willamette and Sandy rivers are foremost on the Oregon side. The majority of this ESU is represented by fall-run fish; there is some question whether any natural-origin spring chinook salmon persist in this ESU. Fourteen hatchery stocks were included in the ESU; one was considered essential for recovery (Cowlitz River spring chinook) but was not listed. Critical habitat was designated for LCR chinook salmon on February 16, 2000 (65 FR 7764).

A.2.2 Steelhead

A.2.2.1 Snake River Steelhead

The SR steelhead ESU, listed as threatened on August 18, 1997 (62 FR 43937), includes all natural-origin populations of steelhead in the Snake River basin of Southeast Washington, northeast Oregon, and Idaho. None of the hatchery stocks in the Snake River basin are listed, but several are included in the ESU. Critical habitat was designated for SR steelhead on February 16, 2000 (65 FR 7764).

A.2.2.2 Upper Columbia River Steelhead

The UCR steelhead ESU, listed as endangered on August 18, 1997 (62 FR 43937), includes all natural-origin populations of steelhead in the Columbia River basin upstream from the Yakima River, Washington, to the U.S./Canada border the Yakima River. The Wells Hatchery stock is included among the listed populations. Critical habitat was designated for UCR steelhead on February 16, 2000 (65 FR 7764).

A.2.2.3 Middle Columbia River Steelhead

The Middle Columbia River (MCR) steelhead ESU, listed as threatened on March 25, 1999 (64 FR 14517), includes all natural-origin populations in the Columbia River basin above the Wind River, Washington, and the Hood River, Oregon, including the Yakima River, Washington. This ESU includes the only populations of winter inland steelhead in the United States (in the

Klickitat River, Washington, and Fifteenmile Creek, Oregon). Both the Deschutes River and Umatilla River hatchery stocks are included in the ESU, but are not listed. Critical habitat was designated for MCR steelhead on February 16, 2000 (65 FR 7764).

A.2.2.4 Upper Willamette River Steelhead

The UWR steelhead ESU, listed as threatened on March 25, 1999 (64 FR 14517), is comprised of all natural-origin populations in the Willamette River and its tributaries upstream of Willamette Falls to the Calapooia River, inclusive. None of the hatchery stocks were included as part of the listed ESU. Critical habitat was designated for UWR steelhead on February 16, 2000 (65 FR 7764).

A.2.2.5 Lower Columbia River Steelhead

The LCR steelhead ESU, listed as threatened on March 19, 1998 (63 FR 13347), is comprised of all natural-origin populations in tributaries to the Columbia River between the Cowlitz and Wind rivers, Washington, and the Willamette and Hood rivers, Oregon, inclusive. NMFS specifically excluded three river basins: (1) the Willamette River basin above Willamette Falls, (2) the Little White Salmon River, and the Big White Salmon River, Washington (61 FR 41545). Among hatchery stocks, late-spawning Cowlitz River Trout Hatchery and late-spawning Clackamas River ODFW stock #122 are part of the ESU but are not considered essential for recovery. Critical habitat was designated for LCR steelhead on February 16, 2000 (65 FR 7764).

A.2.3 Chum Salmon

A.2.3.1 Columbia River Chum Salmon

The Columbia River (CR) chum salmon ESU, listed as threatened on March 25, 1999 (64 FR 14508), includes all natural-origin chum salmon in the Columbia River and its tributaries in Washington and Oregon. None of the hatchery populations are included as part of the listed ESU. Critical habitat was designated for CR chum salmon on February 16, 2000 (65 FR 7764).

A.2.4 Sockeye Salmon

A.2.4.1 Snake River Sockeye Salmon

The SR sockeye salmon ESU, listed as endangered on November 20, 1991 (56 FR 58619), includes populations of sockeye salmon from the Snake River basin, Idaho (extant populations occur only in the Salmon River subbasin). Under NMFS' interim policy on artificial propagation (58 FR 17573), the progeny of fish from a listed population that are propagated artificially are considered part of the listed species and are protected under the ESA. Thus, although not specifically designated in the 1991 listing, SR sockeye salmon produced in the captive broodstock program are included in the listed ESU. Given the dire status of the wild population under any criteria (a total of 23 wild fish returned to Redfish Lake during the 10-year period

1990 through 1999), NMFS considers the captive broodstock and its progeny essential for recovery. Critical habitat was designated for SR sockeye salmon on December 28, 1993 (58 FR 68543).

A.3 GENERAL LIFE HISTORIES

A.3.1 Chinook Salmon

Chinook salmon is the largest of the Pacific salmon. The species' distribution historically ranged from the Ventura River in California to Point Hope, Alaska, in North America, and in northeastern Asia from Hokkaido, Japan, to the Anadyr River in Russia (Healey 1991). Additionally, chinook salmon have been reported in the Mackenzie River area of northern Canada (McPhail and Lindsey 1970). Of the Pacific salmon, chinook salmon exhibit arguably the most diverse and complex life history strategies. Healey (1986) described 16 age categories for chinook salmon, seven total ages with three possible freshwater ages. This level of complexity is roughly comparable to that seen in sockeye salmon (*O. nerka*), although the latter species has a more extended freshwater residence period and uses different freshwater habitats (Miller and Brannon 1982, Burgner 1991). Two generalized freshwater life-history types were initially described by Gilbert (1912): "stream-type" chinook salmon, which reside in freshwater for a year or more following emergence, and "ocean-type" chinook salmon, which migrate to the ocean within their first year. Healey (1983, 1991) has promoted the use of broader definitions for "ocean-type" and "stream-type" to describe two distinct races of chinook salmon. Healey's approach incorporates life history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of chinook salmon populations.

The generalized life history of Pacific salmon involves incubation, hatching, and emergence in freshwater; migration to the ocean; and the subsequent initiation of maturation and return to freshwater for completion of maturation and spawning. The juvenile rearing period in freshwater can be minimal or extended. Additionally, some male chinook salmon mature in freshwater, thereby foregoing emigration to the ocean. The timing and duration of each of these stages is related to genetic and environmental determinants and their interactions to varying degrees. Although salmon exhibit a high degree of variability in life-history traits, there is considerable debate as to what degree this variability is shaped by local adaptation or results from the general plasticity of the salmonid genome (Ricker 1972, Healey 1991, Taylor 1991). More detailed descriptions of the key features of chinook salmon life history can be found in Myers et al. (1998) and Healey (1991).

A.3.2 Steelhead

Steelhead can be divided into two basic run-types based on the state of sexual maturity at the time of river entry and the duration of the spawning migration (Burgner et al. 1992). The stream-maturing type, or summer steelhead, enters fresh water in a sexually immature condition and requires several months in freshwater to mature and spawn. The ocean-maturing type, or winter steelhead, enters fresh water with well-developed gonads and spawns shortly after river entry (Barnhart 1986). Variations in migration timing exist between populations. Some river basins have both summer and winter steelhead, whereas others only have one run-type.

In the Pacific Northwest, summer steelhead enter fresh water between May and October (Busby et al. 1996; Nickelson et al. 1992). During summer and fall, prior to spawning, they hold in cool, deep pools (Nickelson et al. 1992). They migrate inland toward spawning areas, overwinter in the larger rivers, resume migration in early spring to natal streams, and then spawn (Meehan and Bjornn 1991; Nickelson et al. 1992). Winter steelhead enter fresh water between November and April in the Pacific Northwest (Busby et al. 1996; Nickelson et al. 1992), migrate to spawning areas, and then spawn in late winter or spring. Some adults, however, do not enter coastal streams until spring, just before spawning (Meehan and Bjornn 1991). Difficult field conditions (snowmelt and high stream flows) and the remoteness of spawning grounds contribute to the relative lack of specific information on steelhead spawning.

Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death. However, it is rare for steelhead to spawn more than twice before dying and most that do so are females (Nickelson et al. 1992). Iteroparity is more common among southern steelhead populations than northern populations (Busby et al. 1996). Multiple spawnings for steelhead range from 3% to 20% of runs in Oregon coastal streams.

Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity. Intermittent streams may also be used for spawning (Barnhart 1986; Everest 1973). Steelhead enter streams and arrive at spawning grounds weeks or even months before they spawn and are vulnerable to disturbance and predation. Cover, in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence, and turbidity (Giger 1973) are required to reduce disturbance and predation of spawning steelhead. Summer steelhead usually spawn further upstream than winter steelhead (Withler 1966; Behnke 1992).

Depending on water temperature, steelhead eggs may incubate for 1.5 to 4 months (August 9, 1996, 61 FR 41542) before hatching. Summer rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small wood. Some older juveniles move downstream to rear in larger tributaries and mainstem rivers (Nickelson et al. 1992).

Juveniles rear in fresh water from 1 to 4 years, then migrate to the ocean as smolts. Winter steelhead populations generally smolt after 2 years in fresh water (Busby et al. 1996). Steelhead typically reside in marine waters for 2 or 3 years before returning to their natal stream to spawn at 4 or 5 years of age. Populations in Oregon and California have higher frequencies of age-1-ocean steelhead than populations to the north, but age-2-ocean steelhead generally remain dominant (Busby et al. 1996). Age structure appears to be similar to other west coast steelhead, dominated by 4-year-old spawners (Busby et al. 1996).

Based on purse seine catches, juvenile steelhead tend to migrate directly offshore during their first summer rather than migrating along the coastal belt as do salmon. During fall and winter, juveniles move southward and eastward (Hartt and Dell 1986). Oregon steelhead tend to be north-migrating (Nicholas and Hankin 1988; Pearcy et al. 1990; Pearcy 1992).

A.3.3 Chum Salmon

Historically, chum salmon were distributed throughout the coastal regions of western Canada and the United States, as far south as Monterey Bay, California. Presently, major spawning populations are found only as far south as Tillamook Bay on the northern Oregon coast.

Chum salmon (*Oncorhynchus keta*) are semelparous, spawn primarily in freshwater and, apparently, exhibit obligatory anadromy (there are no recorded landlocked or naturalized freshwater populations) (Randall et al. 1987). Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Like pink salmon, chum salmon usually spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to nearly 100 km from the sea. Juveniles outmigrate to seawater almost immediately after emerging from the gravel that covers their redds (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means that survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids which depend heavily on freshwater habitats) than on favorable estuarine conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

A.3.4 Sockeye Salmon

Snake River sockeye salmon adults enter the Columbia River primarily during June and July. Arrival at Redfish Lake, which now supports the only remaining run of Snake River sockeye salmon, peaks in August and spawning occurs primarily in October (Bjornn et al. 1968). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for 3 to 5 weeks, emerge in April through May and move immediately into the lake. Once there, juveniles feed on plankton for 1 to 3 years before they migrate to the ocean (Bell 1986). Migrants leave Redfish Lake during late April through May (Bjornn et al. 1968) and travel almost 900 miles to the Pacific Ocean. Smolts reaching the ocean remain inshore or within the influence of the Columbia River plume during the early summer months. Later, they migrate through the northeast Pacific Ocean (Hart 1973, Hart and Dell 1986). Snake River sockeye salmon usually spend 2 to 3 years in the Pacific Ocean and return in their fourth or fifth year of life. For detailed information on the Snake River sockeye salmon, see Waples et al. (1991).

A.4 POPULATION DYNAMICS AND DISTRIBUTION

The following sections provide specific information on the distribution and population structure (size, variability, and trends of the stocks or populations) of each listed ESU. Most of this information comes from observations made in terminal, freshwater areas, which may be distinct from the action area. This focus is appropriate because the species status and distribution can only be measured at this level of detail as adults return to spawn.

A.4.1 Chinook Salmon

A.4.1.1 Snake River Spring/Summer Chinook Salmon

The present range of spawning and rearing habitat for naturally-spawned SR spring/summer chinook salmon is primarily limited to the Salmon, Grande Ronde, Imnaha, and Tucannon subbasins. Most SR spring/summer chinook salmon enter individual subbasins from May through September. Juvenile SR spring/summer chinook salmon emerge from spawning gravels from February through June (Perry and Bjornn 1991). Typically, after rearing in their nursery streams for about 1 year, smolts begin migrating seaward in April and May (Bugert et al. 1990; Cannamela 1992). After reaching the mouth of the Columbia River, spring/summer chinook salmon probably inhabit nearshore areas before beginning their northeast Pacific Ocean migration, which lasts 2 to 3 years. Because of their timing and ocean distribution, these stocks are subject to very little ocean harvest. For detailed information on the life history and stock status of SR spring/summer chinook salmon, see Matthews and Waples (1991), NMFS (1991a), and 56 FR 29542 (June 27, 1991).

Bevan et al. (1994) estimated the number of wild adult SR spring/summer chinook salmon in the late 1800s to be more than 1.5 million fish annually. By the 1950s, the population had declined to an estimated 125,000 adults. Escapement estimates indicate that the population continued to decline through the 1970s. Returns were variable through the 1980s, but declined further the in recent years. Record low returns were observed in 1994 and 1995. Dam counts were modestly higher from 1996 through 1998, but declined in 1999. For management purposes the spring and summer chinook in the Columbia River basin, including those returning to the Snake River, have been managed as separate stocks. Historical databases therefore provide separate estimates for the spring and summer chinook components. Table A-3 reports the estimated annual return of adult, natural-origin SR spring and summer chinook salmon returning to Lower Granite Dam since 1979.

NMFS set an interim recovery level for SR spring/summer chinook salmon (31,400 adults at Ice Harbor Dam) in its proposed recovery plan (NMFS 1995). The SR spring/summer chinook salmon ESU consists of 39 local spawning populations (subpopulations) spread over a large geographic area (Lichatowich et al. 1993). The number of fish returning to Lower Granite Dam is therefore divided among these subpopulations. The relationships between these subpopulations, and particularly the degree to which individuals may intermix is unknown. It is unlikely that all 39 are independent populations per the definition in McElhany et al. (2000), which requires that each be isolated such that the exchange of individuals between populations does not substantially affect population dynamics or extinction risk over a 100-year time frame. Nonetheless, monitoring the status of subpopulations provides more detailed information on the status of the species than would an aggregate measure of abundance.

Table A-3. Estimates of Natural-Origin SR Spring/Summer Chinook Salmon Counted at Lower Granite Dam in Recent Years (Speaks 2000)

Year	Spring Chinook	Summer Chinook	Total
1979	2,573	2,712	5,285
1980	3,478	2,688	6,166
1981	7,941	3,326	11,267
1982	7,117	3,529	10,646
1983	6,181	3,233	9,414
1984	3,199	4,200	7,399
1985	5,245	3,196	8,441
1986	6,895	3,934	10,829
1987	7,883	2,414	10,297
1988	8,581	2,263	10,844
1989	3,029	2,350	5,379
1990	3,216	3,378	6,594
1991	2,206	2,814	5,020
1992	11,285	1,148	12,433
1993	6,008	3,959	9,967
1994	1,416	305	1,721
1995	745	371	1,116
1996	1,358	2,129	3,487
1997	1,434	6,458	7,892
1998	5,055	3,371	8,426
1999	1,433	1,843	3,276
		Recovery Esc Level	31,440

Seven of these subpopulations have been used as index stocks for the purpose of analyzing extinction risk and alternative actions that may be taken to meet survival and recovery requirements. The Snake River Salmon Recovery Team selected these subpopulations primarily because of the availability of relatively long time series of abundance data. The BRWG developed recovery and threshold abundance levels for the index stocks, which serve as reference points for comparisons with observed escapements (Table A-4). The threshold abundances represent levels at which uncertainties (and thus the likelihood of error) about processes or population enumeration are likely to be biologically significant, and at which qualitative changes in processes are likely to occur. They were specifically not developed as indicators of pseudo-extinction or as absolute indicators of "critical" thresholds. In any case, escapement estimates for the index stocks have generally been well below threshold levels in recent years (Table A-4).

Table A-4. Number of Adult Spawners, Recovery Levels, and BRWG Threshold Abundance Levels

Brood year	Bear Valley	Marsh	Sulphur	Minam	Imnaha	Poverty Flats	Johnson
1979	215	83	90	40	238	76	66
1980	42	16	12	43	183	163	55
1981	151	115	43	50	453	187	102
1982	83	71	17	104	590	192	93
1983	171	60	49	103	435	337	152
1984	137	100	0	101	557	220	36
1985	295	196	62	625	699	341	178
1986	224	171	385	357	479	233	129
1987	456	268	67	569	448	554	175
1988	1109	395	607	493	606	844	332
1989	91	80	43	197	203	261	103
1990	185	101	170	331	173	572	141
1991	181	72	213	189	251	538	151
1992	173	114	21	102	363	578	180
1993	709	216	263	267	1178	866	357
1994	33	9	0	22	115	209	50
1995	16	0	4	45	97	81	20
1996	56	18	23	233	219	135	49
1997	225	110	43	140	474	363	236
1998	372	164	140	122	159	396	119
1999	72	0	0	96	282	153	49
2000	*58*	*19*	*24*	*240*	na	*280*	*102*
Recovery Level	**900**	**450**	**300**	**450**	**850**	**850**	**300**
BRWG Threshold	**300**	**150**	**150**	**150**	**300**	**300**	**150**

These values are for SR spring/summer chinook salmon index stocks. Spring chinook index stocks: Bear Valley, Marsh, Sulphur and Minam. Summer-run index stocks: Poverty Flats and Johnson. Run-timing for the Imnaha is intermediate. Estimates for 2000 (shown in italics) are based on the preseason forecast.

As of June 1, 2000, the preliminary final aggregate count for upriver spring chinook salmon at Bonneville Dam was 178,000, substantially higher than the 2000 forecast of 134,000[1]. This is the second highest return in 30 years (after the 1972 return of 179,300 adults). Only a small portion of these are expected to be natural-origin spring chinook destined for the Snake River (5,800). However, the aggregate estimate for natural-origin SR spring chinook salmon is substantially higher than the contributing brood year escapements. Comparable returns to the Columbia River mouth in 1995 and 1996 were 1,829 and 3,903, respectively. The expected returns to the index areas were estimated by multiplying the anticipated return to the river mouth by factors that accounted for anticipated harvest (approximately 9%), interdam loss (50%),

[1] Source: June 1, 2000, E-mail from R. Bayley (NMFS) to Stephen H. Smith (NMFS). "Spring chinook update (end-of-season at Bonneville Dam)."

prespawning mortality (10%), and the average proportion of total natural-origin spring chinook salmon expected to return to the index areas (14.3%). This rough calculation suggests that the returns to each index area would just replace the primary contributing brood year escapement (1996) (Table A-4). These results also suggest that other areas may benefit more than the index areas in terms of brood year return rates. The index areas, on average, account for about 14% of the return of natural-origin spring chinook stocks to the Snake River. The substantial return of hatchery fish will also provide opportunities to pursue supplementation options designed to help rebuild natural-origin populations subject to constraints related to population diversity and integrity. For example, expected returns of the Tucannon River (500 listed hatchery and wild fish), Imnaha River (800 wild and 1,600 listed hatchery fish), and Sawtooth Hatchery (368 listed hatchery fish) all represent substantial increases over past years and provide opportunities for supplementation in the local basins designed to help rebuild the natural-origin stocks.

The 2000 forecast for the upriver summer chinook stocks is 33,300, which is again the second highest return in over 30 years, but with only a small portion (2,000) being natural-origin fish destined for the Snake River. The return of natural-origin fish compares to brood year escapements in 1995 and 1996 of 534 and 3,046 and is generally lower than the average returns over the last 5 years (3,466). The expect returns to the Poverty Flats and Johnson Creek index areas using methods similar to those described above indicates that returns will approximately double the returns observed during 1996, the primary contributing brood year (Table A-4) and would be at least close to threshold escapement levels. Again, the substantial returns of hatchery fish can be used in selected areas to help rebuild at least some of the natural-origin stocks. Unfortunately, with the exception of the Imnaha, local brood stocks are not currently available for the spring and summer chinook index areas.

The probability of meeting survival and recovery objectives for SR spring/summer chinook under various future operation scenarios for the hydrosystem was analyzed through a process referred to as PATH (Plan for Analyzing and Testing Hypotheses). The scenarios analyzed focused on status quo management and options that emphasized either juvenile transportation or hydro-project drawdown. PATH also included sensitivity analyses to alternative harvest rates and habitat effects. PATH estimated the probability of survival and recovery for the seven index stocks using the recovery and escapement threshold levels as abundance indicators. The forward simulations estimated the probability of meeting the survival thresholds after 24 and 100 years.

A 70% probability of exceeding the threshold escapement levels was used to assess survival. Recovery potential was assessed by comparing the projected abundance to the recovery abundance levels after 48 years. A 50% probability of exceeding the recovery abundance levels was used to evaluate recovery by comparing the eight-year mean projected abundance. In general the survival and recovery standards were met for operational scenarios involving drawdown, but were not met under status quo management or for the scenarios that relied on juvenile trans-portation (Marmorek et al. 1998). If the most conservative harvest rate schedule was assumed, transportation scenarios came very close to meeting the survival and recovery standards.

For the SR spring/summer chinook salmon ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period[2] ranges from 0.94 to 0.66, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to the effectiveness of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated average population growth rates and the risk of absolute extinction within 24 and 100 years for six of the seven spring/summer chinook salmon index stocks, using the same range of assumptions about the relative effectiveness of hatchery fish (no data were available on the proportion of hatchery fish in the seventh population, Bear Creek). At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years for the wild component ranges from 0.01 for Johnson Creek to 1.00 for the Imnaha River (Table A-6a; Appendix B in McClure et al. 2000). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 for the wild components in the Imnaha and Minam rivers (Table A-6d; Appendix B in McClure et al. 2000).

NMFS has also calculated the proportional increase in the average growth rates of the SR spring/summer chinook salmon index stocks that would be needed to reduce the risk of absolute extinction within 100 years to 5% (Tables A-7a through A-7d; Appendix B in McClure et al. 2000). This analysis explored the sensitivity of the results to different methods of projecting population trends 100 years into the future. One of the projections was based on the observed returns from the 1980 through 1994 brood years ("Observed") whereas two also projected returns for the 1995 through 1996 ("Projected-1") and 1995 through 1999 ("Projected-2") brood years, respectively. Assuming that the effectiveness of hatchery fish has been zero, a relatively small change (less than 15%) is needed in the growth rate of the wild population for each of the index populations under all three projections. However, as the relative effectiveness of hatchery-origin spawners increases, the needed change in growth rate also rises, to more than 100% for the Minam River if hatchery-origin spawners have been 100% as effective as wild fish (Table A-7d).

Similar results are shown in Tables A-8a and A-8b for the population growth rate needed for recovery of SR spring/summer chinook salmon index populations. The sensitivity of the recovery metrics to different assumptions methods of projecting population trends into the future is shown in Tables A9a to A9b.

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[2] The estimates of average population growth rate, risk of extinction, and likelihood of meeting recovery goals are based on population trends observed during the base period of 1980 through 1994 (including 1999 adult returns).

Table A-5a. Average Populations Growth Rates (Lambda) and Upper and Lower 95% Confidence Intervals for 11 Columbia River Basin ESUs (i.e., excluding SR sockeye salmon). This analysis incorporates the proportion of natural spawners that were of hatchery origin but assumes that hatchery fish did not reproduce.

Species	ESU	Lambda	Upper 95% CI	Lower 95% CI
Chinook salmon	SR spring/summer-run[1]	0.94	1.06	0.84
	SR fall-run	0.93	1.08	0.81
	UCR spring-run	0.87	0.98	0.78
	UWR	1.01	1.34	0.76
	LCR[1]	0.95	1.20	0.75
Steelhead	SR (A+B-run)	0.90	0.95	0.84
	UCR	0.90	1.02	0.79
	MCR[1]	0.87	0.88	0.87
	UWR	0.91	1.03	0.80
	LCR[1]	0.98	0.99	0.97
Chum salmon[1]		1.03	1.13	0.94

[1] Note: Source: McClure et al. (2000). The spawning aggregations (i.e., variously identified as spawning, index, or subbasin populations) used in these analyses may not constitute a sample that represents the status of the ESU as a whole. For example, the estimate of the growth rate of the SR spring/summer chinook salmon ESU is based on six index stocks, out of a much larger number of identified spawning aggregations. In comparison, the estimate for UWR chinook salmon, based on counts at Willamette Falls, is based on as complete count for the ESU as possible.

Table A-5b. Average Populations Growth Rates (Lambda) and Upper and Lower 95% Confidence Intervals for Eleven Columbia River Basin ESUs (i.e., excluding SR sockeye salmon). This analysis incorporates the proportion of natural spawners that were of hatchery-origin but assumes that hatchery fish have been 20% as productive as spawners of wild origin.

Species	ESU	Lambda	Upper 95% CI	Lower 95% CI
Chinook salmon	SR spring/summer-run[1]	0.87	1.01	0.74
	SR fall-run	0.84	0.97	0.72
	UCR spring-run	0.85	0.96	0.76
	UWR	0.50	0.55	0.45
	LCR[1]	0.86	1.08	0.68
Steelhead	SR (A+B-run)	0.49	0.61	0.40
	UCR	0.63	0.65	0.62
	MCR[1]	0.65	0.68	0.63
	UWR[1]	0.84	0.94	0.76
	LCR	0.72	0.75	0.70
Chum salmon[1]		1.03	1.13	0.94

[1] See note in **Table A-5a**.

Table A-5c. Average Populations Growth Rates (Lambda) and Upper and Lower 95% Confidence Intervals for Eleven Columbia River Basin ESUs (i.e., excluding SR sockeye salmon). This analysis incorporates the proportion of natural spawners that were of hatchery origin but assumes that hatchery fish have been 20% as productive as spawners of wild origin.

Species	ESU	Lambda	Upper 95% CI	Lower 95% CI
Chinook salmon	SR spring/summer-run[1]	0.70	0.88	0.55
	SR fall-run	0.64	0.77	0.54
	UCR spring-run	0.80	0.91	0.70
	UWR	0.20	0.26	0.16
	LCR[1]	0.66	0.84	0.53
Steelhead	SR (A+B-run)	0.21	0.29	0.15
	UCR	0.34	0.39	0.29
	MCR[1]	0.37	0.40	0.35
	UWR	0.70	0.77	0.63
	LCR[1]	0.41	0.44	0.37
Chum salmon[1]		1.03	1.13	0.94

[1] See note in **Table A-5a**.

Table A-5d. Average Populations Growth Rates (Lambda) and Upper and Lower 95% Confidence Intervals for Eleven Columbia River Basin ESUs (i.e., excluding SR sockeye salmon). This analysis incorporates the proportion of natural spawners that were of hatchery origin but assumes that hatchery fish have been 20% as productive as spawners of wild origin.

Species	ESU	Lambda	Upper 95% CI	Lower 95% CI
Chinook salmon	SR spring/summer-run[1]	0.66	0.84	0.51
	SR fall-run	0.59	0.72	0.49
	UCR spring-run	0.78	0.89	0.69
	UWR	0.17	0.22	0.13
	LCR[1]	0.62	0.78	0.49
Steelhead	SR (A+B-run)	0.18	0.24	0.13
	UCR	0.29	0.35	0.25
	MCR[1]	0.33	0.35	0.30
	UWR	0.66	0.74	0.59
	LCR[1]	0.36	0.39	0.32
Chum salmon[1]		1.03	1.13	0.94

[1] See note in **Table A-5a**.

Table A-6a. Estimated initial population size in the CRI Dennis model analyses for individual stocks, average population growth rate (lambda), risk of absolute extinction and the proportional change in lambda needed to reduce the risk of extinction to 5%, and the risk of a 90% decline in abundance. This analysis incorporates the proportion of natural spawners that were of hatchery-origin but assumes that hatchery fish did not reproduce.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda	Change in Lambda 24-Year	Risk of a 90% Decline 100-Year	Risk of a 90% Decline 24-
Chinook Salmon									
SR Spring/Summer ESU									
	Bear Creek[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	1,175	0.89	0.00	1.00	0.000	0.095	0.69	1.00
	Johnson Creek	457	1.00	0.00	0.01	0.000	0.000	0.02	0.20
	Marsh Creek	291	0.94	0.01	0.64	0.000	0.080	0.31	0.85
	Minam River	582	0.90	0.06	0.92	0.010	0.135	0.54	0.98
	Poverty Flats (SF Salmon River)	1,055	1.00	0.00	0.02	0.000	0.000	0.06	0.25
	Sulphur Creek	207	0.97	0.13	0.56	0.070	0.145	0.30	0.53
SR Fall ESU		2,199	0.93	0.00	0.50	0.000	0.040	0.28	0.98
UCR Spring-run ESU									
	Methow River	433	0.93	0.08	0.73	0.030	0.135	0.40	0.82
	Entiat River	173	0.89	0.01	1.00	0.000	0.105	0.71	1.00
	Wenatchee River	805	0.80	0.04	1.00	0.000	0.200	1.00	1.00
UWR ESU									
	McKenzie River (above Leaburg)	6,859	1.02	0.00	0.02	0.000	0.000	0.10	0.16
LCR ESU									
	Bear Creek	507	0.66	0.99	1.00	0.440	0.585	1.00	1.00
	Big Creek	5,964	0.95	0.00	0.12	0.000	0.010	0.15	0.94
	Clatskanie River	57	0.88	0.64	0.98	0.340	0.365	0.60	0.95
	Cowlitz River - 'Tule'[2]	N/A	0.95	N/A	N/A	N/A	N/A	0.24	0.79
	Elochoman Creek[2]	N/A	0.95	N/A	N/A	N/A	N/A	0.37	0.66
	Germany Creek[2]	N/A	1.01	N/A	N/A	N/A	N/A	0.08	0.18
	Gnat Creek	211	0.95	0.25	0.74	0.150	0.205	0.37	0.66
	Grays River - 'Tule'[2]	N/A	0.77	N/A	N/A	N/A	N/A	0.89	1.00
	Kalama River - Spring-run[2]	N/A	0.94	N/A	N/A	N/A	N/A	0.31	0.82
	Kalama River[2]	N/A	1.02	N/A	N/A	N/A	N/A	0.22	0.29
	Klaskanine River	54	0.71	0.99	1.00	0.535	0.580	0.99	1.00
	Lewis River - 'Bright'[2]	N/A	0.99	N/A	N/A	N/A	N/A	0.02	0.27
	Lewis River - Spring-run[2]	N/A	0.95	N/A	N/A	N/A	N/A	0.37	0.68

	Lewis, East Fork - 'Tule'[2]	N/A	0.97	N/A	N/A	N/A	N/A	0.02	0.77

Table A-6a continued.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	100-Year	Change in Lambda	24-Year	Risk of a 90% Decline 100-Year	24-
	Lewis and Clark River	0*	0.58	1.00	1.00	N/A	N/A	0.91	1.00
	**functionally extinct*								
	Mill Creek - Fall-run	615	0.76	0.70	1.00	0.210	0.350	0.98	1.00
	Plympton Creek	5,983	1.00	0.00	0.03	0.000	0.000	0.10	0.26
	Sandy River - Late-run	4,263	0.94	0.00	0.06	0.000	0.005	0.09	1.00
	Sandy River - 'Tule'[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Skamokawa Creek[2]	N/A	0.77	N/A	N/A	N/A	N/A	1.00	1.00
	Youngs River	38	0.77	0.90	1.00	1.115	1.120	0.80	0.99
Steelhead									
SR ESU									
	A-run	299,161	0.91	0.00	0.12	0.000	0.010	0.42	1.00
	B-run	100,455	0.92	0.00	0.35	0.000	0.020	0.38	1.00
UCR ESU		7,708	0.90	0.00	0.95	0.000	0.070	0.61	1.00
MCR ESU									
	Beaver Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Deschutes River - Summer-run	70,501	0.85	0.00	0.00	0.000	0.000	1.00	1.00
	Mill Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Shitike Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Warm Springs - NF Summer-run	1,031	0.90	0.00	0.94	0.000	0.080	0.55	1.00
	Eightmile Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ramsey Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Fifteenmile Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Touchet River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Umatilla River - Summer-run	9,809	0.89	0.00	1.00	0.000	0.035	0.93	1.00
	Yakima River - Summer-run	5,561	0.99	0.00	0.00	0.000	0.000	0.00	0.11
UWR ESU									
	Molalla River	2,644	0.91	0.00	0.77	0.000	0.070	0.47	0.99
	North Santiam River	5,653	0.87	0.00	0.99	0.000	0.100	0.79	1.00
	South Santiam River	3,730	0.98	0.00	0.00	0.000	0.000	0.02	0.46
	Calapooia River	416	0.82	0.35	1.00	0.120	0.260	0.88	1.00
LCR ESU									

	Clackamas River - Summer-run	9,065	0.90	0.00	1.00	0.000	0.050	0.73	1.00
	Clackamas River - Winter-run	3,123	0.99	0.00	0.00	0.000	0.000	0.00	0.12

Table A-6a continued.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda	Change in Lambda 24-Year	Risk of a 90% Decline 100-Year	Risk of a 90% Decline 24-
	Coweeman River - Winter-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Eagle Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Green River - Winter-run	660	0.88	0.09	0.94	0.030	0.165	0.62	0.99
	Hood River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hood River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Kalama River - Summer-run	18,843	1.11	0.00	0.00	0.000	0.000	0.00	0.00
	Kalama River - Winter-run	6,294	1.03	0.00	0.00	0.000	0.000	0.00	0.00
	Lewis River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Panther Creek –Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Sandy River - Winter-run	6,012	0.95	0.00	0.08	0.000	0.005	0.12	0.98
	Toutle River - Winter-run	3,008	0.90	0.00	1.00	0.000	0.000	1.00	1.00
	Trout Creek - Summer-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Washougal River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Washougal River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Wind River - Summer-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SR Sockeye Salmon[3]		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CR Chum Salmon									
	Grays River - WF[2]	N/A	1.14	N/A	N/A	N/A	N/A	0.01	0.00
	Grays River - (mouth to head)[2]	N/A	0.97	N/A	N/A	N/A	N/A	0.18	0.58
	Crazy Johnson Creek[2]	N/A	1.18	N/A	N/A	N/A	N/A	0.00	0.00
	Gorely Springs[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hardy Creek[2]	N/A	1.05	N/A	N/A	N/A	N/A	0.00	0.00
	Hamilton Creek[2]	N/A	0.86	N/A	N/A	N/A	N/A	0.90	1.00
	Ives Island[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hamilton Springs[2]	N/A	1.06	N/A	N/A	N/A	N/A	0.17	0.18

Source: Appendix B in McClure et al. 2000).

N/A indicates the following:

[1] No hatchery data were available.

[2] Data are peak counts and therefore not appropriate for projecting population size into the future.

[3] Data are too sparse to perform any of these analyses.

Table A-6b. Estimated initial population size in the CRI Dennis model analyses for individual stocks, average population growth rate (lambda), risk of absolute extinction and the proportional change in lambda needed to reduce the risk of extinction to 5%, and the risk of a 90% decline in abundance. This analysis incorporates the proportion of natural spawners that were of hatchery-origin but assumes that hatchery fish have been 20% as productive as spawners of wild-origin.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda 24-Year	Change in Lambda 100-Year	Risk of a 90% Decline 24-Year	Risk of a 90% Decline 100-Year
Chinook Salmon									
SR Spring/Summer ESU									
	Bear Creek[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	1,175	0.79	0.23	1.00	0.050	0.240	1.00	1.00
	Johnson Creek	457	1.00	0.00	0.01	0.000	0.000	0.02	0.20
	Marsh Creek	291	0.94	0.01	0.64	0.000	0.080	0.31	0.85
	Minam River	582	0.80	0.48	1.00	0.170	0.305	0.91	1.00
	Poverty Flats (SF Salmon River)	1,055	0.98	0.00	0.08	0.000	0.010	0.10	0.48
	Sulphur Creek	207	0.97	0.13	0.56	0.070	0.145	0.30	0.53
SR Fall ESU		2,199	0.84	0.00	1.00	0.000	0.160	0.96	1.00
UCR Spring-run ESU									
	Methow River	433	0.91	0.11	0.87	0.050	0.160	0.51	0.94
	Entiat River	173	0.82	0.43	1.00	0.050	0.200	1.00	1.00
	Wenatchee River	805	0.79	0.15	1.00	0.025	0.225	1.00	1.00
UWR ESU									
	McKenzie River (above Leaburg)	6,859	0.86	0.02	0.94	0.000	0.160	0.71	1.00
LCR ESU									
	Bear Creek	507	0.55	1.00	1.00	0.710	0.895	1.00	1.00
	Big Creek	5,964	0.79	0.01	1.00	0.000	0.210	1.00	1.00
	Clatskanie River	57	0.73	0.94	1.00	0.585	0.625	0.95	1.00
	Cowlitz River - 'Tule'[2]	N/A	0.79	N/A	N/A	N/A	N/A	0.98	1.00
	Elochoman Creek[2]	N/A	0.79	N/A	N/A	N/A	N/A	0.84	1.00
	Germany Creek[2]	N/A	0.84	N/A	N/A	N/A	N/A	0.84	1.00
	Gnat Creek	211	0.79	0.70	1.00	0.365	0.435	0.84	1.00
	Grays River - 'Tule'[2]	N/A	0.64	N/A	N/A	N/A	N/A	1.00	1.00
	Kalama River - Spring-run[2]	N/A	0.79	N/A	N/A	N/A	N/A	0.97	1.00
	Kalama River[2]	N/A	0.85	N/A	N/A	N/A	N/A	0.68	0.98
	Klaskanine River	54	0.59	1.00	1.00	0.825	0.885	1.00	1.00
	Lewis River - 'Bright'[2]	N/A	0.97	N/A	N/A	N/A	N/A	0.05	0.59

Table A-6b continued.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda 24-Year	Change in Lambda 100-Year	Risk of a 90% Decline 24-Year	Risk of a 90% Decline 100-Year
	Lewis River - Spring-run[2]	N/A	0.79	N/A	N/A	N/A	N/A	0.86	1.00
	Lewis, East Fork - 'Tule'[2]	N/A	0.97	N/A	N/A	N/A	N/A	0.02	0.77
	Lewis and Clark River **functionally extinct*	0*	0.48	1.00	1.00	N/A	N/A	0.97	1.00
	Mill Creek - Fall-run	615	0.64	0.99	1.00	0.440	0.615	1.00	1.00
	Plympton Creek	5,983	0.83	0.03	1.00	0.000	0.190	0.86	1.00
	Sandy River - Late-run	4,263	0.93	0.00	0.14	0.000	0.010	0.14	1.00
	Sandy River - 'Tule'[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Skamokawa Creek[2]	N/A	0.64	N/A	N/A	N/A	N/A	1.00	1.00
	Youngs River	38	0.64	0.98	1.00	1.465	1.475	0.96	1.00
Steelhead									
SR ESU									
	A-run	299,161	0.52	0.99	1.00	0.360	0.835	1.00	1.00
	B-run	100,455	0.48	1.00	1.00	0.480	0.965	1.00	1.00
UCR ESU		7,708	0.63	1.00	1.00	0.000	0.000	1.00	1.00
MCR ESU									
	Beaver Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Deschutes River - Summer-run	70,501	0.59	1.00	1.00	0.180	0.580	1.00	1.00
	Mill Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Shitike Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Warm Springs - NF Summer-run	1,031	0.90	0.00	0.94	0.000	0.080	0.55	1.00
	Eightmile Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ramsey Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Fifteenmile Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Touchet River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Umatilla River - Summer-run	9,809	0.85	0.00	1.00	0.000	0.080	1.00	1.00
	Yakima River - Summer-run	5,561	0.97	0.00	0.00	0.000	0.000	0.00	0.59
UWR ESU									
	Molalla River	2,644	0.79	0.07	1.00	0.010	0.230	0.99	1.00
	North Santiam River	5,653	0.84	0.00	1.00	0.000	0.145	0.95	1.00
	South Santiam River	3,730	0.87	0.00	0.00	0.000	0.000	1.00	1.00

	Calapooia River	416	0.82	0.35	1.00	0.120	0.260	0.88	1.00

Table A-6b continued.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda 24-Year	Change in Lambda 100-Year	Risk of a 90% Decline 24-Year	Risk of a 90% Decline 100-Year
LCR ESU									
	Clackamas River - Summer-run	9,065	0.61	1.00	1.00	0.000	0.000	1.00	1.00
	Clackamas River - Winter-run	3,123	0.67	1.00	1.00	0.000	0.000	1.00	1.00
	Coweeman River - Winter-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Eagle Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Green River - Winter-run	660	0.88	0.09	0.94	0.030	0.165	0.62	0.99
	Hood River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hood River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Kalama River - Summer-run	18,843	0.67	0.67	1.00	0.210	0.495	1.00	1.00
	Kalama River - Winter-run	6,294	0.88	0.00	0.99	0.000	0.075	0.80	1.00
	Lewis River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Panther Creek –Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Sandy River - Winter-run	6,012	0.82	0.00	1.00	0.000	0.160	1.00	1.00
	Toutle River - Winter-run	3,008	0.90	0.00	1.00	0.000	0.000	1.00	1.00
	Trout Creek - Summer-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Washougal River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Washougal River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Wind River - Summer-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SR Sockeye Salmon[3]		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CR Chum Salmon									
	Grays River - WF[2]	N/A	1.14	N/A	N/A	N/A	N/A	0.01	0.01
	Grays River - (mouth to head)[2]	N/A	0.97	N/A	N/A	N/A	N/A	0.18	0.58
	Crazy Johnson Creek[2]	N/A	1.18	N/A	N/A	N/A	N/A	0.00	0.00
	Gorely Springs[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hardy Creek[2]	N/A	1.05	N/A	N/A	N/A	N/A	0.00	0.00
	Hamilton Creek[2]	N/A	0.86	N/A	N/A	N/A	N/A	0.90	1.00
	Ives Island[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hamilton Springs[2]	N/A	1.06	N/A	N/A	N/A	N/A	0.17	0.18

Source: Appendix B in McClure et al. 2000.
N/A indicates the following:
[1] No hatchery data were available.

[2] Data are peak counts and therefore not appropriate for projecting population size into the future.
[3] Data are too sparse to perform any of these analyses.

Table A-6c. Estimated initial population size in the CRI Dennis model analyses for individual stocks, average population growth rate (lambda), risk of absolute extinction and the proportional change in lambda needed to reduce the risk of extinction to 5%, and the risk of a 90% decline in abundance. This analysis incorporates the proportion of natural spawners that were of hatchery-origin but assumes that hatchery fish have been 80% as productive as spawners of wild-origin.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda 24-Year	Change in Lambda 100-Year	Risk of a 90% Decline 24-Year	Risk of a 90% Decline 100-Year
Chinook Salmon									
SR Spring/Summer ESU									
	Bear Creek[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	1,175	0.62	0.93	1.00	0.605	0.770	0.99	1.00
	Johnson Creek	457	1.00	0.00	0.01	0.000	0.000	0.02	0.20
	Marsh Creek	291	0.94	0.01	0.64	0.000	0.080	0.31	0.85
	Minam River	582	0.60	0.98	1.00	0.685	0.835	1.00	1.00
	Poverty Flats (SF Salmon River)	1,055	0.93	0.00	0.64	0.000	0.065	0.36	0.96
	Sulphur Creek	207	0.97	0.13	0.56	0.070	0.145	0.30	0.53
SR Fall ESU		2,199	0.64	0.99	1.00	0.255	0.525	1.00	1.00
UCR Spring-run ESU									
	Methow River	433	0.84	0.27	1.00	0.105	0.235	0.82	1.00
	Entiat River	173	0.65	1.00	1.00	0.300	0.495	1.00	1.00
	Wenatchee River	805	0.75	0.59	1.00	0.095	0.300	1.00	1.00
UWR ESU									
	McKenzie River (above Leaburg)	6,859	0.59	0.97	1.00	0.380	0.690	1.00	1.00
LCR ESU									
	Bear Creek	507	0.36	1.00	1.00	1.520	1.830	1.00	1.00
	Big Creek	5,964	0.53	1.00	1.00	0.425	0.810	1.00	1.00
	Clatskanie River	57	0.49	1.00	1.00	1.320	1.395	1.00	1.00
	Cowlitz River - 'Tule'[2]	N/A	0.53	N/A	N/A	N/A	N/A	1.00	1.00
	Elochoman Creek[2]	N/A	0.53	N/A	N/A	N/A	N/A	1.00	1.00
	Germany Creek[2]	N/A	0.56	N/A	N/A	N/A	N/A	1.00	1.00
	Gnat Creek	211	0.53	1.00	1.00	1.005	1.130	1.00	1.00
	Grays River - 'Tule'[2]	N/A	0.43	N/A	N/A	N/A	N/A	1.00	1.00
	Kalama River - Spring-run[2]	N/A	0.52	N/A	N/A	N/A	N/A	1.00	1.00
	Kalama River[2]	N/A	0.57	N/A	N/A	N/A	N/A	1.00	1.00
	Klaskanine River	54	0.39	1.00	1.00	1.675	1.790	1.00	1.00
	Lewis River - 'Bright'[2]	N/A	0.93	N/A	N/A	N/A	N/A	0.33	1.00

Table A-6c continued.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda 24-Year	Change in Lambda 100-Year	Risk of a 90% Decline 24-Year	Risk of a 90% Decline 100-Year
	Lewis River - Spring-run[2]	N/A	0.53	N/A	N/A	N/A	N/A	1.00	1.00
	Lewis, East Fork - 'Tule'[2]	N/A	0.97	N/A	N/A	N/A	N/A	0.02	0.77
	Lewis and Clark River **functionally extinct*	0*	0.32	1.00	1.00	N/A	N/A	1.00	1.00
	Mill Creek - Fall-run	615	0.42	1.00	1.00	1.125	1.405	1.00	1.00
	Plympton Creek	5,983	0.56	1.00	1.00	0.445	0.775	1.00	1.00
	Sandy River - Late-run	4,263	0.92	0.00	0.06	0.000	0.030	0.37	1.00
	Sandy River - 'Tule'[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Skamokawa Creek[2]	N/A	0.43	N/A	N/A	N/A	N/A	1.00	1.00
	Youngs River	38	0.42	1.00	1.00	2.500	2.520	1.00	1.00
Steelhead									
SR ESU									
	A-run	299,161	0.23	1.00	1.00	2.170	3.285	1.00	1.00
	B-run	100,455	0.20	1.00	1.00	2.515	3.765	1.00	1.00
UCR ESU		7,708	0.34	1.00	1.00	1.210	1.805	1.00	1.00
MCR ESU									
	Beaver Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Deschutes River - Summer-run	70,501	0.31	1.00	1.00	1.230	2.040	1.00	1.00
	Mill Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Shitike Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Warm Springs - NF Summer-run	1,031	0.90	0.00	0.94	0.000	0.080	0.55	1.00
	Eightmile Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ramsey Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Fifteenmile Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Touchet River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Umatilla River - Summer-run	9,809	0.75	0.00	1.00	0.000	0.000	1.00	1.00
	Yakima River - Summer-run	5,561	0.92	0.00	0.17	0.000	0.005	0.11	1.00
UWR ESU									
	Molalla River	2,644	0.57	1.00	1.00	0.410	0.720	1.00	1.00
	North Santiam River	5,653	0.75	0.08	1.00	0.015	0.275	1.00	1.00
	South Santiam River	3,730	0.67	0.77	1.00	0.280	0.525	1.00	1.00
	Calapooia River	416	0.82	0.35	1.00	0.120	0.260	0.88	1.00

Table A-6c continued.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda 24-Year	Change in Lambda 100-Year	Risk of a 90% Decline 24-Year	Risk of a 90% Decline 100-Year
LCR ESU									
	Clackamas River - Summer-run	9,065	0.31	1.00	1.00	0.000	0.000	1.00	1.00
	Clackamas River - Winter-run	3,123	0.34	1.00	1.00	0.000	0.000	1.00	1.00
	Coweeman River - Winter-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Eagle Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Green River - Winter-run	660	0.88	0.09	0.94	0.030	0.165	0.62	0.99
	Hood River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hood River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Kalama River - Summer-run	18,843	0.31	1.00	1.00	1.830	2.410	1.00	1.00
	Kalama River - Winter-run	6,294	0.62	0.96	1.00	0.260	0.565	1.00	1.00
	Lewis River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Panther Creek –Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Sandy River - Winter-run	6,012	0.59	1.00	1.00	0.275	0.620	1.00	1.00
	Toutle River - Winter-run	3,008	0.90	0.00	1.00	0.000	0.000	1.00	1.00
	Trout Creek - Summer-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Washougal River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Washougal River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Wind River - Summer-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SR Sockeye Salmon[3]		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CR Chum Salmon									
	Grays River - WF[2]	N/A	1.14	N/A	N/A	N/A	N/A	0.01	0.01
	Grays River - (mouth to head)[2]	N/A	0.97	N/A	N/A	N/A	N/A	0.18	0.58
	Crazy Johnson Creek[2]	N/A	1.18	N/A	N/A	N/A	N/A	0.00	0.00
	Gorely Springs[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hardy Creek[2]	N/A	1.05	N/A	N/A	N/A	N/A	0.00	0.00
	Hamilton Creek[2]	N/A	0.86	N/A	N/A	N/A	N/A	0.90	1.00
	Ives Island[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hamilton Springs[2]	N/A	1.06	N/A	N/A	N/A	N/A	0.17	0.18

Source: Appendix B in McClure et al. 2000.
N/A indicates the following:
[1] No hatchery data were available.
[2] Data are peak counts and therefore not appropriate for projecting population size into the future.

[3] Data are too sparse to perform any of these analyses.

Table A-6d. Estimated initial population size in the CRI Dennis model analyses for individual stocks, average population growth rate (lambda), risk of absolute extinction and the proportional change in lambda needed to reduce the risk of extinction to 5%, and the risk of a 90% decline in abundance. This analysis incorporates the proportion of natural spawners that were of hatchery-origin but assumes that hatchery fish have been 100% as productive as spawners of wild-origin.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction		Change in Lambda		Risk of a 90% Decline	
				24-Year	100-Year	24-Year	100-Year	24-Year	100-Year
Chinook Salmon									
SR Spring/Summer ESU									
	Bear Creek[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	1,175	0.59	0.95	1.00	0.790	0.955	0.99	1.00
	Johnson Creek	457	1.00	0.00	0.01	0.000	0.000	0.02	0.20
	Marsh Creek	291	0.94	0.01	0.64	0.000	0.080	0.31	0.85
	Minam River	582	0.55	0.99	1.00	0.855	1.015	1.00	1.00
	Poverty Flats (SF Salmon River)	1,055	0.91	0.00	0.82	0.000	0.085	0.47	0.99
	Sulphur Creek	207	0.97	0.13	0.56	0.070	0.145	0.30	0.53
SR Fall ESU		2,199	0.59	1.00	1.00	0.360	0.650	1.00	1.00
UCR Spring-run ESU									
	Methow River	433	0.82	0.35	1.00	0.120	0.260	0.89	1.00
	Entiat River	173	0.61	1.00	1.00	0.390	0.595	1.00	1.00
	Wenatchee River	805	0.74	0.69	1.00	0.120	0.325	1.00	1.00
UWR ESU									
	McKenzie River (above Leaburg)	6,859	0.53	1.00	1.00	0.520	0.870	1.00	1.00
LCR ESU									
	Bear Creek	507	0.33	1.00	1.00	1.785	2.140	1.00	1.00
	Big Creek	5,964	0.47	1.00	1.00	0.575	1.005	1.00	1.00
	Clatskanie River	57	0.44	1.00	1.00	1.560	1.645	1.00	1.00
	Cowlitz River - 'Tule'[2]	N/A	0.48	N/A	N/A	N/A	N/A	1.00	1.00
	Elochoman Creek[2]	N/A	0.48	N/A	N/A	N/A	N/A	1.00	1.00
	Germany Creek[2]	N/A	0.51	N/A	N/A	N/A	N/A	1.00	1.00
	Gnat Creek	211	0.48	1.00	1.00	1.215	1.360	1.00	1.00
	Grays River - 'Tule'[2]	N/A	0.39	N/A	N/A	N/A	N/A	1.00	1.00
	Kalama River - Spring-run[2]	N/A	0.47	N/A	N/A	N/A	N/A	1.00	1.00
	Kalama River[2]	N/A	0.51	N/A	N/A	N/A	N/A	1.00	1.00
	Klaskanine River	54	0.35	1.00	1.00	1.955	2.090	1.00	1.00
	Lewis River - 'Bright'[2]	N/A	0.91	N/A	N/A	N/A	N/A	0.48	1.00

Table A-6d continued.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda 24-Year	Change in Lambda 100-Year	Risk of a 90% Decline 24-Year	Risk of a 90% Decline 100-Year
	Lewis River - Spring-run[2]	N/A	0.47	N/A	N/A	N/A	N/A	1.00	1.00
	Lewis, East Fork - 'Tule'[2]	N/A	0.97	N/A	N/A	N/A	N/A	0.02	0.77
	Lewis and Clark River *functionally extinct*	0*	0.29	1.00	1.00	N/A	N/A	1.00	1.00
	Mill Creek - Fall-run	615	0.38	1.00	1.00	1.350	1.670	1.00	1.00
	Plympton Creek	5,983	0.50	1.00	1.00	0.595	0.970	1.00	1.00
	Sandy River - Late-run	4,263	0.91	0.00	0.82	0.000	0.035	0.46	1.00
	Sandy River - 'Tule'[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Skamokawa Creek[2]	N/A	0.39	N/A	N/A	N/A	N/A	1.00	1.00
	Youngs River	38	0.38	1.00	1.00	2.840	2.870	1.00	1.00
Steelhead									
SR ESU									
	A-run	299,161	0.19	1.00	1.00	2.765	4.100	1.00	1.00
	B-run	100,455	0.17	1.00	1.00	3.185	4.695	1.00	1.00
UCR ESU		7,708	0.29	1.00	1.00	1.560	2.250	1.00	1.00
MCR ESU									
	Beaver Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Deschutes River - Summer-run	70,501	0.26	1.00	1.00	1.570	2.525	1.00	1.00
	Mill Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Shitike Creek - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Warm Springs - NF Summer-run	1,031	0.90	0.00	0.91	0.000	0.080	0.55	1.00
	Eightmile Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ramsey Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Fifteenmile Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Touchet River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Umatilla River - Summer-run	9,809	0.72	0.00	1.00	0.000	0.000	1.00	1.00
	Yakima River - Summer-run	5,561	0.91	0.00	0.00	0.000	0.000	0.54	1.00
UWR ESU									
	Molalla River	2,644	0.52	1.00	1.00	0.550	0.885	1.00	1.00
	North Santiam River	5,653	0.73	0.23	1.00	0.045	0.320	1.00	1.00
	South Santiam River	3,730	0.63	0.88	1.00	0.435	0.670	1.00	1.00
	Calapooia River	416	0.82	0.35	1.00	0.120	0.260	0.88	1.00

Table A-6d continued.

Species ESU	Stream	Initial Pop. Size	Lambda	Risk of Extinction 24-Year	Risk of Extinction 100-Year	Change in Lambda 24-Year	Change in Lambda 100-Year	Risk of a 90% Decline 24-Year	Risk of a 90% Decline 100-Year
LCR ESU									
	Clackamas River - Summer-run	9,065	0.27	1.00	1.00	0.000	0.000	1.00	1.00
	Clackamas River - Winter-run	3,123	0.30	1.00	1.00	0.000	0.000	1.00	1.00
	Coweeman River - Winter-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Eagle Creek - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Green River - Winter-run	660	0.88	0.09	0.94	0.030	0.165	0.62	0.99
	Hood River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hood River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Kalama River - Summer-run	18,843	0.26	1.00	1.00	2.360	3.040	1.00	1.00
	Kalama River - Winter-run	6,294	0.57	1.00	1.00	0.395	0.730	1.00	1.00
	Lewis River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Panther Creek –Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Sandy River - Winter-run	6,012	0.54	1.00	1.00	0.390	0.770	1.00	1.00
	Toutle River - Winter-run	3,008	0.90	0.00	1.00	0.000	0.000	1.00	1.00
	Trout Creek - Summer-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Washougal River - Summer-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Washougal River - Winter-run[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Wind River - Summer-run[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SR Sockeye Salmon[3]		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CR Chum Salmon									
	Grays River - WF[2]	N/A	1.14	N/A	N/A	N/A	N/A	0.01	0.01
	Grays River - (mouth to head)[2]	N/A	0.97	N/A	N/A	N/A	N/A	0.18	0.58
	Crazy Johnson Creek[2]	N/A	1.18	N/A	N/A	N/A	N/A	0.00	0.00
	Gorely Springs[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hardy Creek[2]	N/A	1.05	N/A	N/A	N/A	N/A	0.00	0.00
	Hamilton Creek[2]	N/A	0.86	N/A	N/A	N/A	N/A	0.90	1.00
	Ives Island[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hamilton Springs[2]	N/A	1.06	N/A	N/A	N/A	N/A	0.17	0.18

Source: Appendix B in McClure et al. 2000.
N/A indicates the following:

[1] No hatchery data were available.

[2] Data are peak counts and therefore not appropriate for projecting population size into the future.

[3] Data are too sparse to perform any of these analyses.

Table A-6e. Estimated initial population size in QAR model analysis for UCR spring chinook salmon and UCR steelhead, median annual population growth rate (lambda), median spawner replacement rate (generation growth rate), risk of absolute extinction, and the proportional change in lambda needed to reduce the risk of absolute extinction to 5%. Analysis incorporates the proportion of natural spawners that were of hatchery origin but assumes that hatchery fish have been 100% as productive as wild spawners.

ESU/Pop	Initial Pop Size	Brood Years	Generation Growth Rate	Lambda	Risk of Absolute Extinction	
					24-Year	100-Year
UCR spring chinook salmon						
Wenatchee	193	1980 - 1994	0.42	0.90	0.07	0.98
Entiat	45	1980 - 1994	0.41	0.91	0.16	0.99
Methow	173	1980 - 1994	0.53	0.97	0.01	0.61
UCR steelhead						
Wenatchee/Entiat	2,000	1976 - 1996	0.41	0.82	--	1.00
Methow	1,750	1976 - 1996	0.28	0.78	0.05	1.00

Table A-6f. Estimated initial population size in QAR model analysis for UCR steelhead, median annual population growth rate (lambda), median spawner replacement rate (generation growth rate), risk of absolute extinction, and the proportional change in lambda needed to reduce the risk of absolute extinction to 5%. Analysis incorporates the proportion of natural spawners that were of hatchery origin but assumes that hatchery fish have been either 25% or 75% as productive as wild spawners.

ESU/Pop	Initial Pop Size	Brood Years	Generation Growth Rate	Lambda	Risk of Absolute Extinction	
					24-Year	100-Year
Hatchery Spawners 25% Effective						
Wenatchee/Entiat	950	1976 - 1996	0.70	0.94	--	0.22
Methow	600	1976 - 1996	0.65	0.97	--	0.28
Hatchery Spawners 75% Effective						
Wenatchee/Entiat	1,700	1976 - 1996	0.46	0.85	--	1.00
Methow	1,400	1976 - 1996	0.33	0.81	--	1.00

Table A-7a. Effect of different methods of projecting population trends 100 years into the future on average population growth rate (λ), risk of absolute extinction, and proportional change in lambda needed to reduce the probability of absolute extinction to 5%. Estimates are shown for the assumption that hatchery fish spawning in the wild do not reproduce (no data are available on the relative effectiveness of hatchery-origin spawners for Bear Creek).

					Risk of Absolute Extinction		Increase in λ	
	Index Stock	λ	λ + 95% CI	λ - 95% CI	24-Yr	100-Yr	24-Yr	100-Yr
Observed	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.89	0.993	0.799	0.000	0.996	0.000	0.095
	Johnson Creek	1.00	1.119	0.884	0.000	0.010	0.000	0.000
	Marsh Creek	0.94	1.141	0.779	0.012	0.640	0.000	0.080
	Minam River	0.90	1.114	0.729	0.063	0.924	0.010	0.135
	Poverty Flats (SF Salmon River)	1.00	1.159	0.856	0.000	0.019	0.000	0.000
	Sulphur Creek	0.97	0.371	0.689	0.127	0.560	0.070	0.145
Projected-1	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.91	1.019	0.810	0.000	0.903	0.000	0.075
	Johnson Creek	1.00	1.101	0.899	0.000	0.003	0.000	0.000
	Marsh Creek	0.95	1.122	0.805	0.003	0.509	0.000	0.060
	Minam River	0.93	1.146	0.758	0.014	0.665	0.000	0.095
	Poverty Flats (SF Salmon River)	1.00	1.139	0.875	0.000	0.006	0.000	0.000
	Sulphur Creek	0.97	1.298	0.720	0.089	0.546	0.040	0.125
Projected-2	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.96	1.096	0.835	0.000	0.252	0.000	0.035
	Johnson Creek	1.03	1.134	0.928	0.000	0.000	0.000	0.000
	Marsh Creek	0.98	1.136	0.845	0.000	0.167	0.000	0.025
	Minam River	0.98	1.179	0.808	0.003	0.257	0.000	0.045
	Poverty Flats (SF Salmon River)	1.02	1.149	0.910	0.000	0.000	0.000	0.000
	Sulphur Creek	0.99	1.264	0.775	0.038	0.353	0.000	0.080

Source: Appendix B in McClure et al. (2000).

Note: Estimates labeled "Observed" are based on actual returns from the 1980 through 1994 brood years (i.e., adult returns through 1999). "Projected-1" are based on the observed data set plus projected returns through 2001 (based on jack returns through 1999). "Projected-2" are based on the observed data set plus projected returns through 2001 (from jacks) and projected returns for 2002 through 2004 (from the average for the 1980 through 2001 period). See McClure et al. (2000).

Table A-7b. Effect of different methods of projecting population trends 100 years into the future on average population growth rate (λ), risk of absolute extinction, and proportional change in lambda needed to reduce the probability of absolute extinction to 5%. Estimates are shown for the assumption that hatchery fish spawning in the wild are 20% as productive as wild-origin spawners (no data are available on the relative effectiveness of hatchery-origin spawners for Bear Creek).

					Risk of Absolute Extinction		Increase in λ	
	Index Stock	λ	λ + 95% CI	λ - 95% CI	24-Yr	100-Yr	24-Yr	100-Yr
Observed	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.79	0.908	0.691	0.229	1.000	0.050	0.240
	Johnson Creek	1.00	1.119	0.884	0.000	0.010	0.000	0.000
	Marsh Creek	0.94	1.141	0.779	0.012	0.640	0.000	0.080
	Minam River	0.80	1.025	0.621	0.483	1.000	0.170	0.305
	Poverty Flats (SF Salmon River)	0.98	1.141	0.839	0.000	0.077	0.000	0.010
	Sulphur Creek	0.97	1.371	0.689	0.127	0.560	0.070	0.145
Projected-1	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.80	0.907	0.706	0.088	1.000	0.020	0.220
	Johnson Creek	1.00	1.101	0.899	0.000	0.003	0.000	0.000
	Marsh Creek	0.95	1.122	0.805	0.003	0.509	0.000	0.060
	Minam River	0.82	1.039	0.652	0.249	0.999	0.100	0.255
	Poverty Flats (SF Salmon River)	0.98	1.123	0.859	0.000	0.033	0.000	0.000
	Sulphur Creek	0.97	1.298	0.720	0.089	0.546	0.040	0.125
Projected-2	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.84	0.962	0.733	0.024	1.000	0.000	0.175
	Johnson Creek	1.026	1.134	0.928	0.000	0.000	0.000	0.000
	Marsh Creek	0.98	1.136	0.845	0.000	0.167	0.000	0.025
	Minam River	0.86	1.058	0.700	0.119	0.983	0.045	0.195
	Poverty Flats (SF Salmon River)	1.01	1.138	0.894	0.000	0.002	0.000	0.000
	Sulphur Creek	0.99	1.264	0.775	0.038	0.353	0.000	0.080

Source: Appendix B in McClure et al. (2000).

See note for **Table A-7a.**

Table A-7c. Effect of different methods of projecting population trends 100 years into the future on average population growth rate (λ), risk of absolute extinction, and proportional change in lambda needed to reduce the probability of absolute extinction to 5%. Estimates are shown for the assumption that hatchery fish spawning in the wild are 80% as productive as wild-origin spawners (no data are available on the relative effectiveness of hatchery-origin spawners for Bear Creek).

					Risk of Absolute Extinction		Increase in λ	
	Index Stock	**λ**	**λ + 95% CI**	**λ - 95% CI**	**24-Yr**	**100-Yr**	**24-Yr**	**100-Yr**
Observed	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.62	0.916	0.423	0.927	1.000	0.605	0.077
	Johnson Creek	1.000	1.119	0.884	0.000	0.010	0.000	0.000
	Marsh Creek	0.94	1.141	0.779	0.012	0.640	0.000	0.080
	Minam River	0.60	0.859	0.418	0.979	1.000	0.685	0.835
	Poverty Flats (SF Salmon River)	0.93	1.090	0.792	0.000	0.637	0.000	0.065
	Sulphur Creek	0.97	1.371	0.689	0.127	0.560	0.070	0.145
Projected-1	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.61	0.856	0.440	0.932	1.000	0.550	0.750
	Johnson Creek	1.00	1.101	0.899	0.000	0.003	0.000	0.000
	Marsh Creek	0.95	1.122	0.805	0.003	0.509	0.000	0.060
	Minam River	0.61	0.843	0.447	0.957	1.000	0.565	0.750
	Poverty Flats (SF Salmon River)	0.94	1.080	0.812	0.000	0.466	0.000	0.050
	Sulphur Creek	0.97	1.298	0.720	0.089	0.546	0.040	0.125
Projected-2	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.64	0.839	0.480	0.901	1.000	0.455	0.665
	Johnson Creek	1.03	1.134	0.928	0.000	0.000	0.000	0.000
	Marsh Creek	0.98	1.136	0.845	0.000	0.167	0.000	0.025
	Minam River	0.64	0.834	0.489	0.934	1.000	0.470	0.660
	Poverty Flats (SF Salmon River)	0.97	1.111	0.848	0.000	0.102	0.000	0.015
	Sulphur Creek	0.99	1.264	0.775	0.038	0.353	0.000	0.080

Source: Appendix B in McClure et al. (2000).
See note for **Table A-7a**.

Table A-7d. Effect of different methods of projecting population trends 100 years into the future on average population growth rate (λ), risk of absolute extinction, and proportional change in lambda needed to reduce the probability of absolute extinction to 5%. Estimates are shown for the assumption that hatchery fish spawning in the wild are 100% as productive as wild-origin spawners (no data are available on the relative effectiveness of hatchery-origin spawners for Bear Creek).

					Risk of Absolute Extinction		Increase in λ	
	Index Stock	**λ**	**λ + 95% CI**	**λ - 95% CI**	**24-Yr**	**100-Yr**	**24-Yr**	**100-Yr**
Observed	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.59	0.921	0.373	0.948	1.000	0.790	0.955
	Johnson Creek	1.00	1.119	0.884	0.000	0.010	0.000	0.000
	Marsh Creek	0.94	1.141	0.779	0.012	0.640	0.000	0.080
	Minam River	0.55	0.818	0.375	0.992	1.000	0.855	1.015
	Poverty Flats (SF Salmon River)	0.91	1.074	0.777	0.001	0.815	0.000	0.085
	Sulphur Creek	0.97	1.371	0.689	0.127	0.560	0.070	0.145
Projected-1	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.57	0.847	0.389	0.957	1.000	0.740	0.935
	Johnson Creek	1.00	1.101	0.899	0.000	0.003	0.000	0.000
	Marsh Creek	0.95	1.122	0.805	0.003	0.509	0.000	0.060
	Minam River	0.57	0.797	0.403	0.984	1.000	0.720	0.920
	Poverty Flats (SF Salmon River)	0.92	1.067	0.798	0.000	0.670	0.000	0.065
	Sulphur Creek	0.97	1.298	0.720	0.089	0.546	0.040	0.125
Projected-2	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.59	0.816	0.428	0.947	1.000	0.625	0.840
	Johnson Creek	1.03	1.134	0.928	0.000	0.000	0.000	0.000
	Marsh Creek	0.98	1.136	0.845	0.000	0.167	0.000	0.025
	Minam River	0.59	0.783	0.442	0.979	1.000	0.620	0.820
	Poverty Flats (SF Salmon River)	0.96	1.102	0.833	0.000	0.209	0.000	0.030
	Sulphur Creek	0.99	1.264	0.775	0.038	0.353	0.000	0.080

Source: Appendix B in McClure et al. (2000).
See note for **Table A-7a**.

Table A-8a. Estimated initial population size in the Dennis model analyses for individual stocks, average population growth rate (lambda), growth rate needed to reach the recovery goal, and the proportional change in growth rate needed to reach the recovery goal. This analysis incorporates the proportion of natural spawners that were of hatchery-origin but assumes that hatchery fish have been 20% as productive as spawners of wild-origin.

Species ESU	Stream	Initial Pop. Size	Lambda	Lambda for Recovery 48-Year	Lambda for Recovery 100-Year	Change in Lambda 48-Year	Change in Lambda 100-Year
Chinook Salmon							
Snake River Spring/Summer ESU							
	Bear Creek[1]	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	1,175	0.79	1.044	1.020	31.745	28.726
	Johnson Creek	457	1.00	1.027	1.012	3.178	1.712
	Marsh Creek	291	0.94	1.069	1.031	13.409	9.392
	Minam River	582	0.80	1.052	1.023	31.840	28.277
	Poverty Flats (SF Salmon River)	1,055	0.98	0.028	1.013	5.110	3.521
	Sulphur Creek	207	0.97	1.068	1.031	9.946	6.070
Snake River Fall ESU		2,199	0.84	1.048	1.022	25.334	22.194
Upper Columbia River Spring-run ESU							
	Methow River	433	0.91	N/A	N/A	N/A	N/A
	Entiat River	173	0.82	N/A	N/A	N/A	N/A
	Wenatchee River	805	0.79	1.072	1.032	36.080	31.048
Steelhead							
Upper Columbia River ESU		7,708	0.63				

"N/A" indicates that no hatchery data were available[1], that the data are peak counts and therefore not appropriate for projecting population size into the future[2], or that data are too sparse to perform any of these analyses[3].

Source: Appendix B in McClure et al. (2000)

Table A-8b. Estimated initial population size in the Dennis model analyses for individual stocks, average population growth rate (lambda)growth rate needed to reach the recovery goal, and the proportional change in growth rate needed to reach the recovery goal. This analysis incorporates the proportion of natural spawners that were of hatchery-origin but assumes that hatchery fish have been 80% as productive as spawners of wild-origin.

Species ESU	Stream	Initial Pop. Size	Lambda	Lambda for Recovery 48-Year	100-Year	Change in Lambda 48-Year	100-Year
Chinook Salmon							
Snake River Spring/Summer ESU							
	Bear Creek[1]	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	1,175	0.62	1.044	1.020	67.569	63.729
	Johnson Creek	457	1.00	1.027	1.012	3.178	1.712
	Marsh Creek	291	0.94	1.069	1.031	13.409	9.392
	Minam River	582	0.60	1.052	1.023	75.562	70.817
	Poverty Flats (SF Salmon River)	1,055	0.93	1.028	1.013	10.748	9.085
	Sulphur Creek	207	0.97	1.068	1.031	9.946	6.070
Snake River Fall ESU		2,199	0.64	1.048	68.689	1.022	59.588
Upper Columbia River Spring-run ESU							
	Methow River	433	0.84	N/A	N/A	N/A	N/A
	Entiat River	173	0.65	N/A	N/A	N/A	N/A
	Wenatchee River	805	0.75	1.072	42.577	1.032	37.304
Steelhead							
Upper Columbia River ESU		7,708	0.34				

Table A-9a. Effect of different methods of projecting population trends 100 years into the future on average population growth rate (λ), growth rate needed to reach the recovery goal, and the change in growth rate needed to reach the recovery goal. Estimates are shown for the assumption that hatchery fish spawning in the wild are 20% as productive as wild-origin spawners (no data are available on the relative effectiveness of hatchery-origin spawners for Bear Creek).

					Lambda for Recovery		Change in Lambda	
	Index Stock	**λ**	**λ + 95% CI**	**λ - 95% CI**	**48-Year**	**100-Year**	**48-Year**	**100-Year**
Observed	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.79	0.908	0.691	1.044	1.020	31.745	28.726
	Johnson Creek	1.00	1.119	0.884	1.027	1.012	3.178	1.712
	Marsh Creek	0.94	1.141	0.779	1.069	1.031	13.409	9.392
	Minam River	0.80	1.025	0.621	1.052	1.023	31.840	28.277
	Poverty Flats (SF Salmon River)	0.98	1.141	0.839	0.028	1.013	5.110	3.521
	Sulphur Creek	0.97	1.371	0.689	1.068	1.031	9.946	6.070
Projected-1	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.80	0.907	0.706	1.044	1.020	30.462	27.472
	Johnson Creek	1.00	1.101	0.899	1.027	1.012	3.225	1.759
	Marsh Creek	0.95	1.122	0.805	1.069	1.031	12.430	8.448
	Minam River	0.82	1.039	0.652	1.052	1.023	27.843	24.388
	Poverty Flats (SF Salmon River)	0.98	1.123	0.859	1.028	1.013	4.694	3.122
	Sulphur Creek	0.97	1.298	0.720	1.069	1.031	10.522	6.655
Projected-2	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.84	0.962	0.733	1.044	1.020	24.347	21.498
	Johnson Creek	1.026	1.134	0.928	1.027	1.012	0.095	-1.327
	Marsh Creek	0.98	1.136	0.845	1.069	1.031	9.056	5.193
	Minam River	0.86	1.058	0.700	1.052	1.023	22.259	18.955
	Poverty Flats (SF Salmon River)	1.01	1.138	0.894	1.028	1.013	1.911	0.381
	Sulphur Creek	0.99	1.264	0.775	1.069	1.031	7.973	4.167

Note: Estimates labeled "Observed" are based on actual returns from the 1980 through 1994 brood years (i.e., adult returns through 1999). "Projected-1" are based on the observed data set plus projected returns through 2001 (based on jack returns through 1999). "Projected-2" are based on the observed data set plus projected returns through 2001 (from jacks) and projected returns for 2002 through 2004 (from the average for the 1980 through 2001 period). See McClure et al. (2000).

Source: Appendix B in McClure et al. (2000)

Table A-9b. Effect of different methods of projecting population trends 100 years into the future on average population growth rate (λ), growth rate needed to reach the recovery goal, and the change in growth rate needed to reach the recovery goal Estimates are shown for the assumption that hatchery fish spawning in the wild are 80% as productive as wild-origin spawners (no data are available on the relative effectiveness of hatchery-origin spawners for Bear Creek).

	Index Stock	λ	λ + 95% CI	λ - 95% CI	Lambda for Recovery 48-Year	Lambda for Recovery 100-Year	Change in Lambda 48-Year	Change in Lambda 100-Year
Observed	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.62	0.916	0.423	1.044	1.020	67.569	63.729
	Johnson Creek	1.000	1.119	0.884	1.027	1.012	3.178	1.712
	Marsh Creek	0.94	1.141	0.779	1.069	1.031	13.409	9.392
	Minam River	0.60	0.859	0.418	1.052	1.023	75.562	70.817
	Poverty Flats (SF Salmon River)	0.93	1.090	0.792	1.028	1.013	10.748	9.085
	Sulphur Creek	0.97	1.371	0.689	1.068	1.031	9.946	6.070
Projected-1	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.61	0.856	0.440	1.044	1.020	70.052	66.154
	Johnson Creek	1.00	1.101	0.899	1.027	1.012	3.225	1.759
	Marsh Creek	0.95	1.122	0.805	1.069	1.031	12.430	8.448
	Minam River	0.61	0.843	0.447	1.052	1.023	71.323	66.693
	Poverty Flats (SF Salmon River)	0.94	1.080	0.812	1.028	1.013	9.780	8.132
	Sulphur Creek	0.97	1.298	0.720	1.069	1.031	10.552	6.655
Projected-2	Bear Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Imnaha River	0.64	0.839	0.480	1.044	1.020	64.481	60.711
	Johnson Creek	1.03	1.134	0.928	1.027	1.012	0.095	-1.327
	Marsh Creek	0.98	1.136	0.845	1.069	1.031	9.056	5.193
	Minam River	0.64	0.834	0.489	1.052	1.023	64.760	66.308
	Poverty Flats (SF Salmon River)	0.97	1.111	0.848	1.028	1.013	5.960	4.369
	Sulphur Creek	0.99	1.264	0.775	1.069	1.031	7.973	4.167

See note for **Table A9a**.

A.4.1.2 Snake River Fall Chinook Salmon

The spawning grounds between Huntington (RM 328) and Auger Falls (RM 607) were historically the most important for this species. Only limited spawning activity was reported downstream from RM 273 (Waples et al. 1991a), about 1 mile upstream of Oxbow Dam. Since then, irrigation and hydrosystem projects on the mainstem Snake River have blocked access to or inundated much of this habitat—causing the fish to seek out less-preferable spawning grounds wherever they are available. Natural fall chinook salmon spawning now occurs primarily in the Snake River below Hells Canyon Dam and the lower reaches of the Clearwater, Grand Ronde, Salmon, and Tucannon rivers.

Adult SR fall chinook salmon enter the Columbia River in July and migrate into the Snake River from August through October. Fall chinook salmon generally spawn from October through November and fry emerge from March through April. Downstream migration generally begins within several weeks of emergence (Becker 1970, Allen and Meekin 1973), and juveniles rear in backwaters and shallow water areas through mid-summer prior to smolting and migrating to the ocean—thus they exhibit an "ocean" type juvenile history. Once in the ocean, they spend 1 to 4 years (though usually, 3) before beginning their spawning migration. Fall returns in the Snake River system are typically dominated by four-year-old fish. For detailed information on SR fall chinook salmon, see NMFS (1991b) and June 27, 1991, 56 FR 29542.

No reliable estimates of historical abundance are available, but because of their dependence on mainstem habitat for spawning, fall chinook have probably been affected to a greater extent by the development of irrigation and hydroelectric projects than any other species of salmon. It has been estimated that the mean number of adult SR fall chinook salmon declined from 72,000 in the 1930s and 1940s to 29,000 during the 1950s. In spite of this, the Snake River remained the most important natural production area for fall chinook in the entire Columbia River basin through the 1950s. The number of adults counted at the uppermost Snake River mainstem dams averaged 12,720 total spawners from 1964 to 1968, 3,416 spawners from 1969 to 1974, and 610 spawners from 1975 to 1980 (Waples et al. 1991a).

Counts of adult fish of natural-origin continued to decline through the 1980s reaching a low of 78 individuals in 1990 (Table A-8). Since then, the return of natural-origin fish to Lower Granite Dam has been variable, but generally increasing reaching a recent year high of 797 in 1997. The 1998 return declined to 306. This was not anticipated and is of particular concern because it is close to the low threshold escapement level of 300 that is indicative of increased risk (BRWG 1994). It has been suggested that the low return in 1998 was due to severe flooding in 1995 that affected the primary contributing brood year. The expected return of natural-origin adults to Lower Granite Dam in 1999 given the anticipated ocean and inriver fisheries is 518.

Table A-8. Escapement and Stock Composition of Fall Chinook at Lower Granite (LGR) Dam[1]

				Stock Comp. of Escapement to LGR		
					Hatchery Origin	
Year	LGR Dam Count	Marked Fish to Lyons Ferry Hatch.	LGR Dam Escapement	Wild	Snake R.	Non-Snake R.
1975	1,000		1,000	1,000		
1976	470		470	470		
1977	600		600	600		
1978	640		640	640		
1979	500		500	500		
1980	450		450	450		
1981	340		340	340		
1982	720		720	720		
1983	540		540	428	112	
1984	640		640	324	310	6
1985	691		691	438	241	12
1986	784		784	449	325	10
1987	951		951	253	644	54
1988	627		627	368	201	58
1989	706		706	295	206	205
1990	385	50	335	78	174	83
1991	630	40	590	318	202	70
1992	855	187	668	549	100	19
1993	1,170	218	952	742	43	167
1994	791	185	606	406	20	180
1995	1,067	430	637	350	1	286
1996	1,308	389	919	639	74	206
1997	1,451	444	1,007	797	20	190
1998	1,909	947	962	306	479	177
1999[2]	3,381	1,519	1,862	905	882	75

[1] Information taken from *Revised Tables for the Biological Assessment of Impacts of Anticipated 1996-1998 Fall Season Columbia River Mainstem and Tributary Fisheries on SR Salmon Species Listed Under the Endangered Species Act*, prepared by the U.S. v. Oregon Technical Advisory Committee.

[2] Source: Memorandum from Glen Mendel (WDFW) to Cindy LeFluer (WDFW) dated March 3, 2000. "Fall chinook run reconstruction at LGR for 1999."

The recovery standard identified in the 1995 Proposed Recovery Plan (NMFS 1995) for SR fall chinook was a population of at least 2,500 naturally produced spawners (to be calculated as an 8-year geometric mean) in the lower Snake River and its tributaries. The adult counts at Lower Granite Dam cannot be compared directly to the natural spawner escapement because it is also necessary to account for adults which may fall back below the dam after counting and prespawning mortality. A preliminary estimate suggested that a Lower Granite Dam count of 4,300 would be necessary to meet the 2,500-fish escapement goal (NMFS 1995). For comparison, the geometric mean of the Lower Granite Dam counts of natural-origin fall chinook over the last 8 years is 481.

A further consideration regarding the status of SR fall chinook is the existence of the Lyons Ferry Hatchery stock which is considered part of the ESU. There have been several hundred adults returning to the Lyons Ferry Hatchery in recent years (Table A-8). More recently, supplementation efforts designed to accelerate rebuilding were initiated beginning with smolt outplants from the 1995 brood year. The existence of the Lyons Ferry program has been an important consideration in evaluating the status of the ESU because it reduces the short-term risk of extinction by providing a reserve of fish from the ESU. Without the hatchery program the risk of extinction would have to be considered high because the ESU would otherwise be comprised of a few hundred individuals from a single population, in marginal habitat, with a demonstrated record of low productivity. Although the supplementation program likely contributes future natural origin spawners, it does little to change the productivity of the system upon which a naturally spawning population must rely. Supplementation is, therefore, not a long-term substitute for recovery. (See NMFS [1999a] for further discussion of the SR fall chinook supplementation program.)

Recent analyses conducted through the PATH process considered the prospects for survival and recovery given several future management options for the hydrosystem and other mortality sectors (Marmorek et al. 1998, Peters et al. 1999). That analysis indicated that the prospects of survival for SR fall chinook were good, but that full recovery was relatively unlikely except under a very limited range of assumptions, or unless draw down was implemented for at least the four lower Snake River dams operated by the U.S. Army Corps of Engineers. Consideration of the draw down options led to a high likelihood that both survival and recovery objectives could be achieved.

For the SR fall chinook salmon ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period ranges from 0.93 to 0.59, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated the risk of absolute extinction within 24 and 100 years for the aggregate SR fall chinook population, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.50 (Table A-6a). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 (Table A-6d).

NMFS has also calculated the proportional increase in the average growth rate of the aggregate SR fall chinook salmon population that would be needed to reduce the risk of absolute extinction within 100 years to 5% (Tables A-6a through A-6d; Appendix B in McClure et al. 2000). Assuming that the effectiveness of hatchery fish has been zero, a relatively small change (4%) is needed in the growth rate of the wild population (Table A-6a). The needed change in growth rate rises to 65% if hatchery-origin spawners have been 100% as effective as wild fish (Table A-6d).

Similar results are shown in Tables A-8a and A-8b for the population growth rate needed for recovery of the aggregate SR fall chinook salmon population. The sensitivity of the recovery metrics to different assumptions methods of projecting population trends into the future is shown in Tables A9a to A9b.

A.4.1.3 Upper Columbia River Spring-Run Chinook Salmon

The UCR spring-run chinook ESU inhabits tributaries upstream from the Yakima River to Chief Joseph Dam. UCR spring-run chinook have a stream-type life history. Adults return to the Wenatchee River during late March through early May, and to the Entiat and Methow rivers during late March through June. Most adults return after spending 2 years in the ocean, although 20% to 40% return after 3 years at sea. Like SR spring/summer chinook, UCR spring-run chinook experience very little ocean harvest. Peak spawning for all three populations occurs from August to September. Smolts typically spend 1 year in freshwater before migrating downstream. There are slight genetic differences between this ESU and others containing stream-type fish, but more importantly, the ESU boundary was defined using ecological differences in spawning and rearing habitat (Myers et al. 1998). The Grand Coulee Fish Maintenance Project (1939 through 1943) may have had a major influence on this ESU because fish from multiple populations were mixed into one relatively homogenous group and redistributed into streams throughout the upper Columbia region.

Three independent populations of spring-run chinook salmon are identified for the ESU including those that spawn in the Wenatchee, Entiat, and Methow basins (Ford et al. 1999). The number of natural-origin fish returning to each subbasin is shown in Table A-9. NMFS recently proposed Interim Recovery Abundance Levels and Cautionary Levels (i.e., interim levels still under review and are subject to change). Ford et al. (1999) characterize Cautionary Levels as abundance levels that the population fell below only about 10% of the time during a historical period when it was considered to be relatively healthy. Escapements for UCR spring-run chinook salmon have been substantially below the Cautionary Levels in recent years, especially 1995, indicating increasing risk to and uncertainty about the population's future status. On the other hand, preliminary returns for 1999, the primary return year for the 1995 brood, indicate that although they were low, returns were still substantially higher than the estimated cohort replacement level. Very strong 1999 jack returns suggest that survival rates for the 1996 brood will be high, as well. A total of 4,500 natural-origin UCR spring-run chinook are expected to return to the mouth of the Columbia River during 2000 with a corresponding expected return to each subbasin (accounting for expected harvest, inter-dam loss, and prespawning mortality) at approximately its respective Cautionary Level (Table A-9).

Table A-9. Estimates of the Number of Natural-Origin Fish Returning to Subbasin for Each Independent Population of UCR Spring-Run Chinook Salmon and Preliminary Interim Recovery Abundance and Cautionary Levels

Year	Wenatchee River	Entiat River	Methow River
1979	1,154	241	554
1980	1,752	337	443
1981	1,740	302	408
1982	1,984	343	453
1983	3,610	296	747
1984	2,550	205	890
1985	4,939	297	1,035
1986	2,908	256	778
1987	2,003	120	1,497
1988	1,832	156	1,455
1989	1,503	54	1,217
1990	1,043	223	1,194
1991	604	62	586
1992	1,206	88	1,719
1993	1,127	265	1,496
1994	308	74	331
1995	50	6	33
1996	201	28	126
1997	422	69	247
1998	218	52	125
1999 [1]	119	64	73
2000	*1,295*	*180*	*811*
Recovery Abundance	**3,750**	**500**	**2,000**
Cautionary Abundance	**1,200**	**150**	**750**

[1] Estimates for 1999 are preliminary; estimates for 2000 (*italics*) are based on the preseason forecast.

Six hatchery populations are included in the listed ESU; all six are considered essential for recovery. Recent artificial production programs for fishery enhancement and hydrosystem mitigation have been a concern because a non-native (Carson Hatchery) stock was used. However, programs have been initiated to develop locally-adapted brood stocks to supplement natural populations and facilities where straying and interactions with natural stock are known problems are phasing out use of Carson stock. Captive broodstock conservation programs are under way in Nason Creek and White River (the Wenatchee basin) and in the Twisp River (Methow basin), to prevent the extinction of those spawning populations. All spring chinook salmon passing Wells Dam in 1996 and 1998 were trapped and brought into the hatchery to begin a composite-stock broodstock supplementation program for the Methow basin.

For the UCR spring-run chinook salmon ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period ranges from 0.87 to 0.78, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated average population growth rates and the risk of absolute extinction within 24 and 100 years for the three spawning populations identified by Ford et al. (1999), using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from 0.73 for the Methow River to 1.00 for the Methow and Entiat rivers (Table A-6a; Appendix B in McClure et al. 2000). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of extinction within 100 years is 1.00 for all three spawning populations (Table A-6d; Appendix B in McClure et al. 2000).

NMFS has also calculated the proportional increase in the average growth rates of each population that would be needed to reduce the risk of absolute extinction within 100 years to five% (Tables A-6a through A-6d; Appendix B in McClure et al. 2000). Assuming that the effectiveness of hatchery fish has been zero, relatively small changes ($\leq$20%) are needed in the growth rates of each of the wild populations (Table A-6a). The needed change in growth rate rises as high as 60% for the Entiat River population if hatchery-origin spawners have been 100% as effective as wild fish (Table A-6d).

Similar results are shown in Tables A-8a and A-8b for the population growth rate needed for recovery of the Wenatchee River spring chinook salmon population. The sensitivity of the recovery metrics to different assumptions methods of projecting population trends into the future is shown in Tables A9a to A9b.

NMFS has also used population risk assessments for Upper Columbia spring chinook and steelhead ESU's from the draft Quantitative Analysis Report (Cooney, 2000 DRAFT). Risk assessments described in that report were based on Monte Carlo simulations with simple spawner/spawner models that incorporate estimated smolt carrying capacity. Population dynamics were simulated for three separate spawning populations in the UCR spring chinook salmon ESU, the Wenatchee, Entiat and Methow populations. The QAR assessments showed extinction risks for UCR spring chinook salmon of 61% for the Methow and 99% for the Entiat spawning populations (Table A6e). These estimates are based on the assumption that the median return rate for the 1980 brood year to the 1994 brood year series will continue into the future.

The QAR analyses also include estimates of the percent change in the spawner replacement rate necessary to meet survival and recovery criteria. For UCR spring chinook salmon, the percent change in survival necessary to reduce the risk of absolute extinction to less than 5% within 100 years ranged from 29% for the Methow population to 75% for the Wenatchee (Table A-10). Substantial improvements in survival are needed to meet recovery levels for all three spawning populations. The estimated survival changes required to meet or exceed the interim Recovery Criteria established by the Upper Columbia River Steelhead and Spring Chinook Salmon Biological Requirements Committee ranged from 95% (Methow) to 175% (Wenatchee).

A.4.1.4 Upper Willamette River Chinook Salmon

UWR chinook salmon are one of the most distinct groups in the Columbia basin — genetically, in terms of age structure, and in terms of their marine distribution (64 FR 14322). The narrow time window available for passage above Willamette Falls (at Willamette RKm 42) may have limited migratory access to the upper basin to spring periods of high flow (Howell et al. 1985), providing reproductive isolation and thereby defining the boundary of a distinct biogeographic region. Winter steelhead and spring-run chinook salmon were indigenous above the falls, but summer steelhead, fall chinook salmon, and coho salmon were not (Busby et al. 1996). Because the Willamette Valley was not glaciated during the last epoch (McPhail and Lindsey 1970), any reproductive isolation provided by the falls would have been uninterrupted for a considerable time period, providing the potential for significant local adaptation relative to other Columbia basin populations.

The life history of chinook salmon in the Upper Willamette River ESU includes traits from both ocean- and stream-type development strategies: smolts emigrate both as young-of-the-year and as age-1 fish. Mattson (1962) reported three distinct migrations of juvenile spring chinook salmon in the lower Willamette River (Lake Oswego area), including movements of a given year class during late winter through spring (age-0 migrants; 40 to 100 mm), late fall-early winter (age-1 fish; 100-130 mm), and then during the following spring (age-2 fish; 100 to 140 mm). Smolt and fry migration patterns at Leaburg Dam in the McKenzie River appear to have shifted over the years; samples collected between 1948 and 1968 indicated that fry emigrated primarily during March through June (Howell et al. 1988) but now peak during January through April (earlier than in previous years) (Corps 2000). Distribution in the ocean is consistent with an ocean-type life history (the majority are caught off the coasts of British Columbia and Southeast Alaska).

Historically, five major basins produced spring chinook salmon: the Clackamas, North and South Santiam, McKenzie, and Middle Fork Willamette rivers. However, between 1952 and 1968, dams were built on all of the major tributaries occupied by spring chinook, blocking over half the most productive spawning and rearing habitat. Water management operations have also reduced habitat quality in downstream areas due to thermal effects (relatively warm water released during autumn, leads to the early emergence of stream-type chinook fry, and cold water released during spring reduces juvenile growth rates).

Table A-10. QAR analysis of percent change in spawner replacement rate needed to reduce extinction risk for UCR spring chinook salmon and UCR steelhead to less than 5% and to meet recovery criteria developed by the Upper Columbia River Steelhead and Spring Chinook Salmon Biological Requirements Committee. Analysis incorporates the proportion of natural spawners that were of hatchery origin but assumes that hatchery fish have been 100% as productive as wild spawners.

ESU	Gen Growth Rate	Lambda	Change in Lambda to Reduce ExtinctionRisk		Change in Lambda to Meet Recovery Criteria	
			24-Year	100-Year	48-Year	100-Year
UCR spring chinook salmon						
Wenatchee	0.42	0.90	0.08	0.75	1.55	1.75
Entiat	0.41	0.91	--	0.57	1.12	1.00
Methow	0.53	0.97	--	0.29	1.05	0.95
UCR steelhead						
Hatchery Effectiveness = 0.25						
Wenatchee/Entiat	0.70	0.94	0.00	0.12	0.00	0.50
Methow	0.65	0.97	0.00	0.15	0.00	0.55
Hatchery Effectiveness = 0.75						
Wenatchee/Entiat	0.46	0.85	0.00	0.67	0.00	1.20
Methow	0.33	0.81	0.00	0.55	0.00	2.00

Spring chinook on the Clackamas River were denied access to the upper watershed after 1917, when the fish ladder washed out at Faraday Dam, but recolonized the system after 1939, when the ladder was repaired. Based on the information available, NMFS has not been able to determine whether the recolonization of the Clackamas system was human-mediated. Regardless, NMFS included natural-origin spring chinook salmon from the Clackamas subbasin as part of the listed ESU and considers this spawning population a potentially important genetic resource for recovery.

Information provided by ODFW (1998) indicates that, at present, the only significant natural production of spring-run chinook salmon above Willamette Falls occurs in the McKenzie River basin. Nicholas (1995) also suggested that a self-sustaining population exists in the North Santiam River basin (BRT 1998) but ODFW contends that the thermal profile of water released from Detroit Dam significantly reduces the survival of any progeny from naturally-spawning fish 64 FR 14308. The McKenzie River may now account for 50% of the production potential in the Willamette River basin, with 80% of that above Leaburg Dam. The number of natural-origin fish counted at Leaburg Dam increased from 786 in 1994 to 1,364 in 1998 (Table A-11).

The Clackamas River currently accounts for about 20% of the production potential in the Willamette River basin, originating from one hatchery plus natural production areas that are primarily located above the North Fork Dam. The interim escapement goal for the area above North Fork Dam is 2,900 fish (ODFW 1998a). However, the system is so heavily influenced by hatchery production that it is difficult to distinguish spawners of natural- from hatchery origin. Approximately 1,000 to 1,500 adults have been counted at the North Fork Dam in recent years.

More than 70% of the production capacity of the North Santiam system was blocked when Detroit Dam was built without passage facilities. The remaining downstream habitat is adversely affected by the temperature effects (i.e., warm water) of flow regulation. This system has also been substantially influenced by hatchery production, although the original genetic resource has been maintained as the Marion Forks Hatchery stock (ODFW 1998a). Despite these limitations, natural spawning continues in the lower river. The count of 194 redds in the area below Minto Dam (the lower-most dam) during 1998 was marginally higher than during either of the prior two years (Lindsay et al. 1998). The origin of these spawning adults has not been determined (although some coded-wire tag recoveries from Santiam River hatcheries have been recovered) nor has their reproductive success.

Mitigation hatcheries were built to offset the substantial habitat losses that resulted from dam construction. As a result, 85% to 95% of the production in the basin is now of hatchery origin. Although the hatchery programs have maintained broodlines that are relatively free of genetic influences from outside the basin, they may have homogenized within-basin stocks, reducing the population structure within the ESU. Prolonged artificial propagation of the majority of the production from this ESU may also have reduced the ability of Willamette River spring-run chinook salmon to reproduce successfully in the wild. Five of six existing hatchery stocks were included in the ESU but none were listed or considered essential for recovery.

The spring run has been counted at Willamette Falls since 1946 but jacks were not differentiated from the total count until 1952. The geometric mean of the estimated run size for the period 1946 through 1950 was 43,300 fish, compared to an estimate for the most recent 5-year period (1994 through 1998) of 25,500 (Table 22 in ODFW and WDFW 1999 and Table A-11). Nicholas (1995) estimated only 3,900 natural spawners in 1994 for the ESU, approximately 1,300 of these naturally produced. The number of naturally-spawning fish has increased gradually in recent years, but NMFS believes that many are first-generation hatchery fish.

For the UWR chinook salmon ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period ranges from 1.01 to 0.17, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated the risk of absolute extinction within 24 and 100 years for the aggregate Upper Columbia River chinook salmon population in the McKenzie River, above Leaburg, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.02 (Table A-6a). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 (Table A-6d).

NMFS has also calculated the proportional increase in the average growth rate of the aggregate McKenzie River population that would be needed to reduce the risk of absolute extinction within 100 years to 5% (Tables A-6a through A-6d; Appendix B in McClure et al. 2000). Assuming that the effectiveness of hatchery fish has been zero, no change is needed in the growth rate of the wild population (Table A-6a). The needed change in growth rate rises to 87% if hatchery-origin spawners have been 100% as effective as wild fish (Table A-6d).

Table A-11. Run Size of Spring Chinook at the Mouth of the Willamette River and Counts at Willamette Falls and Leaburg Dam on the McKenzie River

Return Year	Estimated Number Entering Willamette River	Willamette Falls Count	Leaburg Dam Count	
			Combined	Wild Only
1985	57,100	34,533	825	
1986	62,500	39,155	2,061	
1987	82,900	54,832	3,455	
1988	103,900	70,451	6,753	
1989	102,000	69,180	3,976	
1990	106,300	71,273	7,115	
1991	95,200	52,516	4,359	
1992	68,000	42,004	3,816	
1993	63,900	31,966	3,617	
1994	47,200	26,102	1,526	786
1995	42,600	20,592	1,622	894
1996	34,600	21,605	1,445	1,086
1997	35,000	26,885	1,176	981
1998	45,100	34,461	1,874	1,364
1999	58,000	40,410	1,458	1,416

Source: Nicholas 1995; ODFW and WDFW 1998). The Leaburg counts show wild and hatchery counts combined since 1985 and wild counts only since 1994. Estimates for 1999 are preliminary.

A.4.1.5 Lower Columbia River Chinook Salmon

The LCR chinook salmon ESU includes spring stocks as well as fall tule and bright components. Spring-run chinook salmon on the Lower Columbia River, like those from coastal stocks, enter freshwater in March and April well in advance of spawning in August and September. Historically, the spring migration was synchronized with periods of high rainfall or snowmelt to provide access to upper reaches of most tributaries, where spring stocks would hold until spawning (Fulton 1968, Olsen et al. 1992, WDF et al. 1993).

Fall chinook predominate lower Columbia River salmon runs. Fall chinook return to the river in mid-August and spawn within a few weeks (WDF et al. 1993, Kostow 1995). The majority of fall-run chinook salmon emigrate to the marine environment as subyearlings (Reimers and Loeffel 1967, Howell et al. 1985, WDF et al. 1993). Returning adults that emigrated as yearling smolts may have originated from the extensive hatchery programs within the ESU. It is also possible that modifications in the river environment have altered the duration of freshwater residence. Adult fall-run fish return to tributaries in the lower Columbia River at 3- and 4-years of age compared to 4- to 5-years for spring-run fish. This difference may be related to the predominance of yearling smolts among spring-run stocks. Marine coded-wire-tag recoveries for LCR stocks tend to occur off the British Columbia and Washington coasts, although a small proportion of the tags are recovered in Alaskan waters.

There are no reliable estimates of historical abundance for this ESU, but it is generally agreed that natural production has been greatly reduced over the last century. Recent abundance estimates include a 5-year (1991 through 1995) geometric mean natural spawning escapement of 29,000 natural spawners and 37,000 hatchery spawners. However, according to the accounting of PFMC (1996), approximately 68% of the natural spawners are first-generation hatchery strays.

Hatchery programs to enhance chinook salmon fisheries in the lower Columbia River began in the 1870s, expanded rapidly, and have continued throughout this century. Although the majority of hatchery stocks have come from within this ESU, over 200 million fish from outside the ESU have been released since 1930. A particular concern noted at the time of listing related to the straying by Rogue River fall-run chinook salmon, which are released into the lower Columbia River to augment harvest. The release strategy has since been modified to minimize straying, but it is too early to assess the effect of the change. Available evidence indicates a pervasive influence of hatchery fish on most natural populations of LCR chinook salmon, including both spring- and fall-run populations (Howell et al. 1985, Marshall et al. 1995). In addition, the exchange of eggs between hatcheries in this ESU has led to the extensive genetic homogenization of hatchery stocks (Utter et al. 1989).

The remaining spring chinook stocks in the LCR chinook salmon ESU are found in the Sandy River, Oregon, and the Lewis, Cowlitz, and Kalama rivers, Washington. Spring chinook in the Clackamas River are considered part of the UWR chinook salmon ESU. Despite substantial influence of fish from hatcheries in the UWR ESU in past years, naturally spawning spring chinook salmon in the Sandy River are included in the LCR chinook salmon ESU because they probably contain the remainder of the original genetic legacy for that system. Recent escapements above Marmot Dam on the Sandy River average 2,800 and have been increasing (ODFW 1998b). Hatchery-origin spring chinook are no longer released above Marmot Dam; the proportion of first generation hatchery fish in the escapement is relatively low, on the order of 10% to 20% in recent years. In 1999, the escapement dropped to 1,828 fish, in part because only unmarked “naturally produced” fish were passed over Marmot Dam (Schroeder et al. 1999).

On the Washington side, spring chinook were native to the Cowlitz and Lewis rivers and there is anecdotal evidence that a distinct spring run existed in the Kalama River subbasin (WDF 1951). The Lewis River spring run was severely affected by dam construction. During the period between the construction of Merwin Dam in 1932 and Yale Dam in the early 1950s, WDF attempted to maintain the run by collecting adults at Ariel/Merwin for hatchery propagation or (in years when returns were in excess of hatchery needs) release to the spawning grounds (WDF 1951). As native runs dwindled, Cowlitz spring-run chinook salmon were reintroduced in an effort to maintain them. In the Kalama River, escapements of less than 100 fish were present until the early 1960s when spring-run hatchery production was initiated with a number of stocks from outside the basin. Recent (1994 through 1998) average estimates for naturally spawning spring chinook are 235, 224, and 372 fish in the Cowlitz, Kalama, and Lewis rivers, respectively. Some (perhaps a large) proportion of the natural spawners in each system is believed to be hatchery strays (ODFW 1998b). Although, the Lewis and Kalama hatchery stocks have been mixed with out-of-basin stocks, they are included in the ESU. The Cowlitz River hatchery stock is largely free of introductions. Although it is considered essential for recovery it is not listed because the state of Washington’s hatchery and harvest practices were considered sufficiently protective of this stock that their future existence and value for recovery are not at risk (64 FR 14321). Numbers of spring chinook returning to the Cowlitz, Kalama, and Lewis rivers have declined in recent years, but still number several hundred to a few thousand in each system (Table A-12).

There are apparently three self-sustaining natural populations of tule chinook in the lower Columbia River (Coweeman, East Fork Lewis, and Clackamas) that are not substantially influenced by hatchery strays. Returns to the East Fork and Coweeman have been stable and near interim escapement goals in recent years. Recent 5- and 10-year average escapements to the East Fork Lewis River have been about 300 compared to an interim escapement goal of 300. Recent 5- and 10-year average escapements to the Coweeman River are 900 and 700, respectively compared to an interim natural escapement goal of 1,000 (pers. comm., from G. Norman, WDFW to P. Dygert NMFS, February 22, 1999). Natural escapement on the Clackamas has averaged about 350 in recent years. There have been no releases of hatchery fall chinook in the Clackamas since 1981 and there are apparently few hatchery strays. The population is considered depressed, but stable and self-sustaining (ODFW 1998b). There is some natural spawning of tule fall chinook in the Wind and Little White Salmon rivers, tributaries above Bonneville Dam (the only component of the ESU that is affected by Tribal fisheries). Although there may be some natural production in these systems, the spawning results primarily from hatchery-origin strays.

Escapement of LCR bright fall chinook salmon to the North Fork Lewis River exceeded its escapement goal of 5,700 by a substantial margin every year from the 1970s until 1978. However, runs have been declining and, probably combined with the effect of the 1996 and 1997 floods on habitat, the 1999 return was low (about 2,300). A return of 2,700 is forecast for 2000 (PFMC 2000).

There are two smaller populations of LCR bright fall chinook salmon in the Sandy and East Fork Lewis rivers. Run sizes in the Sandy River have averaged about 1,000 and have been stable for the last 10 to 12 years. The fall chinook hatchery program in the Sandy River was discontinued in 1977, with the intention of reducing the number of hatchery strays in the system. There is also a late spawning component in the East Fork Lewis River that is comparable in timing to the other 'bright' stocks. The escapement of these fish is less well documented, but it appears to be stable and largely unaffected by hatchery fish (ODFW 1998b).

All basins in the region are affected to varying degrees by habitat degradation. Major habitat problems are related primarily to blockages, forest practices, urbanization in the Portland and Vancouver areas, and agriculture in flood plains and low-gradient tributaries. Substantial chinook salmon spawning habitat has been blocked (or passage substantially impaired) in the Cowlitz (Mayfield Dam 1963, RKm 84), Lewis (Merwin Dam 1931, RKm 31), Clackamas (North Fork Dam 1958, RKm 50), Hood (Powerdale Dam 1929, RKm 7), and Sandy (Marmot Dam 1912, RKm 48; Bull Run River dams in the early 1900s) rivers (WDF et al. 1993, Kostow 1995).

For the LCR chinook salmon ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period ranges from 0.95 to 0.62, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated the risk of absolute extinction within 24 and 100 years for ten subbasin populations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from 0.03 for Plympton Creek to 1.00 for Bear and Mill creeks and the Klaskanine and Youngs rivers (Table A-6a). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 for all but one of the 10 subbasin populations (0.82 for the Sandy River late run; Table A-6d). The Lewis and Clark River population is functionally extinct.

NMFS has also calculated the proportional increase in the average growth rate of each subbasin population that would be needed to reduce the risk of absolute extinction within 100 years to 5% (Tables A-6a through A-6d; Appendix B in McClure et al. 2000). Assuming that the effectiveness of hatchery fish has been zero, the needed change in the growth rate of the wild population ranges from zero in Plympton Creek to 112% in the Youngs River (Table A-6a). The needed change in growth rate rises as high as 287% in the Youngs River if hatchery-origin spawners have been 100% as effective as wild fish (Table A-6d).

Table A-12. Estimated LCR Adult Spring Chinook Salmon Returns to Tributaries, 1992 Through 1999

Year	Sandy River	Cowlitz River	Lewis River	Kalama River	Total Returns (Excluding Willamette)
1992	8,600	10,400	5,600	2,400	27,200
1993	6,400	9,500	6,600	3,000	25,500
1994	3,500	3,100	3,000	1,300	10,900
1995	2,500	2,200	3,700	700	9,100
1996	4,100	1,800	1,700	600	8,200
1997	5,200	1,900	2,200	600	9,900
1998	4,300	1,100	1,600	400	7,400
1999		1,600	1,900	600	

Source: Pettit 1998, ODFW and WDFW 1999

A.4.2 Steelhead

A.4.2.1 Snake River Steelhead

The longest consistent indicator of steelhead abundance in the Snake River basin is based on counts of natural-origin steelhead at the uppermost dam on the lower Snake River. The abundance of natural-origin summer steelhead at the uppermost dam on the Snake River has declined from a 4-year average of 58,300 in 1964 to an average of 8,300 ending in 1998. In general, steelhead abundance declined sharply in the early 1970s, rebuilt modestly from the mid-1970s through the 1980s, and again declined during the 1990s (Figure A-1).

These broad scale trends in the abundance of steelhead were reviewed through the PATH process. The PATH report concluded that the initial, substantial decline coincided with the declining trend in downstream passage survival. However, the more recent decline in abundance, observed over the last decade or more, does not coincide with declining passage survival but can be at least partially be accounted for by a shift in climatic regimes that has affected ocean survival (Marmorek 1998).

The abundance of A-run versus B-run components of Snake River basin steelhead can be distinguished in data collected since 1985. Both components have declined through the 1990s, but the decline of B-run steelhead has been more significant. The 4-year average counts at Lower Granite Dam declined from 18,700 to 7,400 beginning in 1985 for A-run steelhead and from 5,100 to 900 for B-run steelhead. Counts over the last 5 or 6 years have been stable for A-run steelhead and without significant trend (Figure A-2). Counts for B-run steelhead have been low and highly variable, but also without apparent trend (Figure A-3).

Comparison of recent dam counts with escapement objectives provides perspective regarding the status of the ESU. The management objective for SR steelhead stated in the Columbia River Fisheries Management Plan was to return 30,000 natural/wild steelhead to Lower Granite Dam. The All Species Review (TAC 1997) further clarified that this objective was subdivided into 20,000 A-run and 10,000 B-run steelhead. Idaho has reevaluated these escapement objectives using estimates of juvenile production capacity. This alternative methodology lead to revised estimates of 22,000 for A-run and 31,400 for B-run steelhead (pers. comm., S. Keifer, IDFG. with P. Dygert, NMFS).

The State of Idaho has conducted redd count surveys in all of the major subbasins since 1990. Although the surveys are not intended to quantify adult escapement, they can be used as indicators of relative trends. The sum of redd counts in natural-origin B-run production subbasins declined from 467 in 1990 to 59 in 1998 (Figure A-4). The declines are evident in all four of the primary B-run production areas. Index counts in the natural-origin A-run production areas have not been conducted with enough consistency to permit similar characterization.

Figure A-1. Adult Returns of Wild Summer Steelhead to the Uppermost Dam on the Snake River

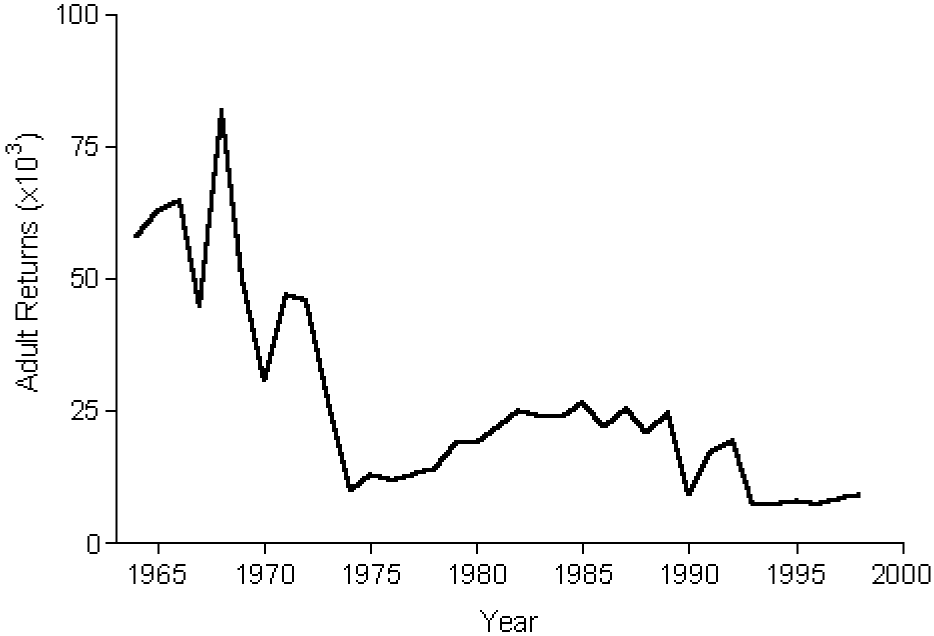
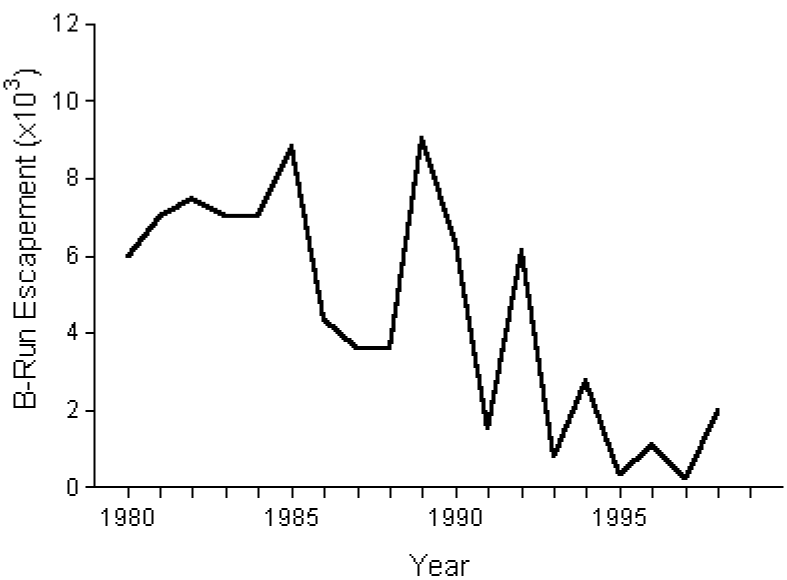
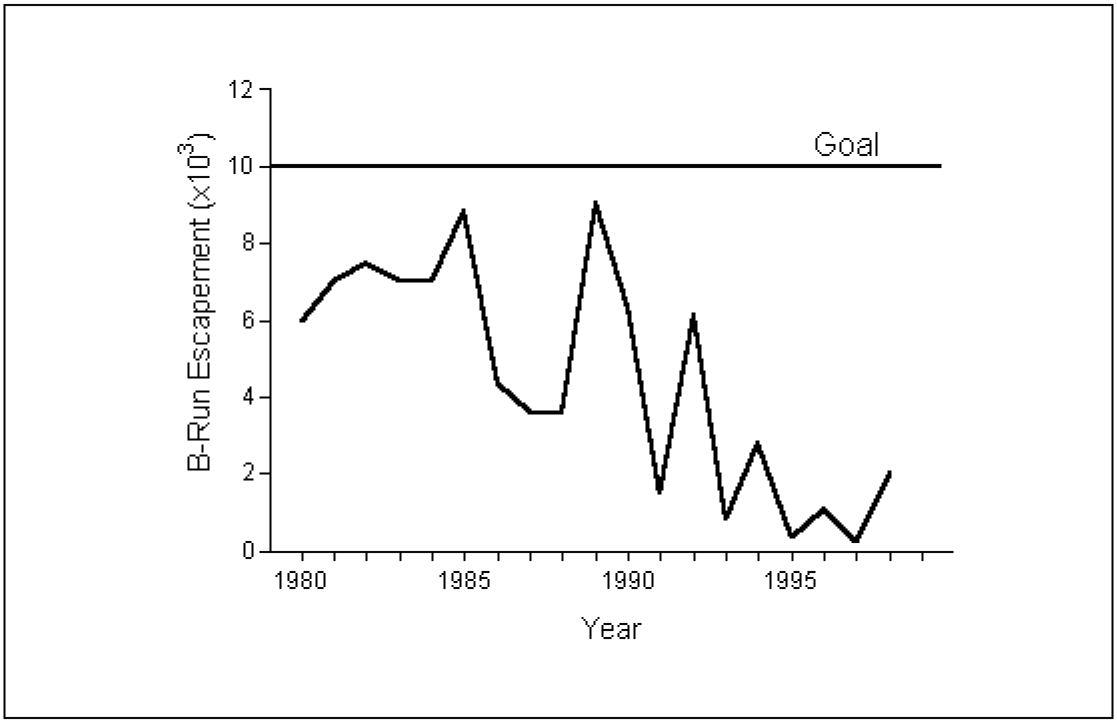


Figure A-2. Escapement of A-Run Snake River Steelhead to the Uppermost Dam[1]



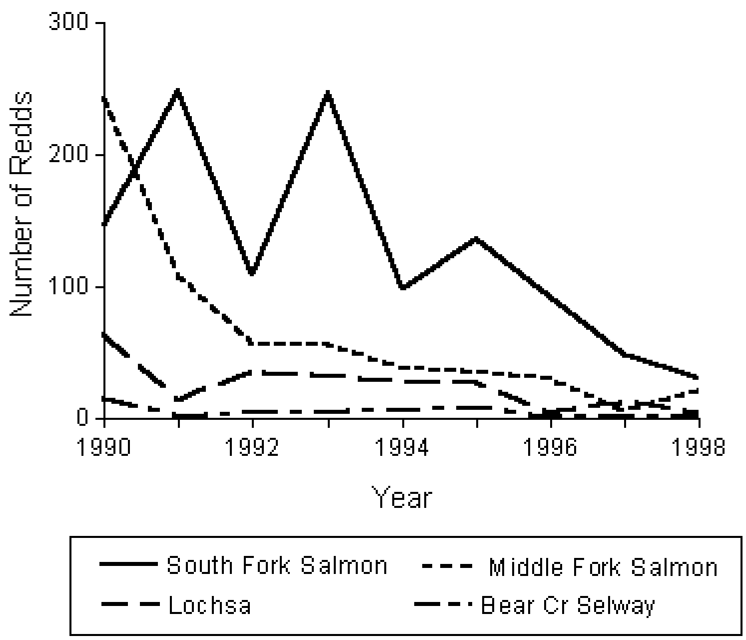
[1] Source: Data for 1980 through 1984 from Figures 1 and 2 of Section 8 in TAC (1997). Data for 1985 through 1998 from Table 2 of Section 8 (TAC 1997) and pers. comm. G. Mauser, IDFG.

Figure A-3. Escapement of B-Run Snake River Steelhead to the Uppermost Dam[1]



[1] Source: Data for 1980 through 1984 from Figures 1 and 2 of Section 8 in TAC (1997). Data for 1985 through 1998 from Table 2 of Section 8 (TAC 1997) and pers. comm. G. Mauser, IDFG.

Figure A-4. Redd Counts for Wild Snake River (B-Run) Steelhead in the South Fork and Middle Fork Salmon, Lochsa, and Bear Creek-Selway Index Areas

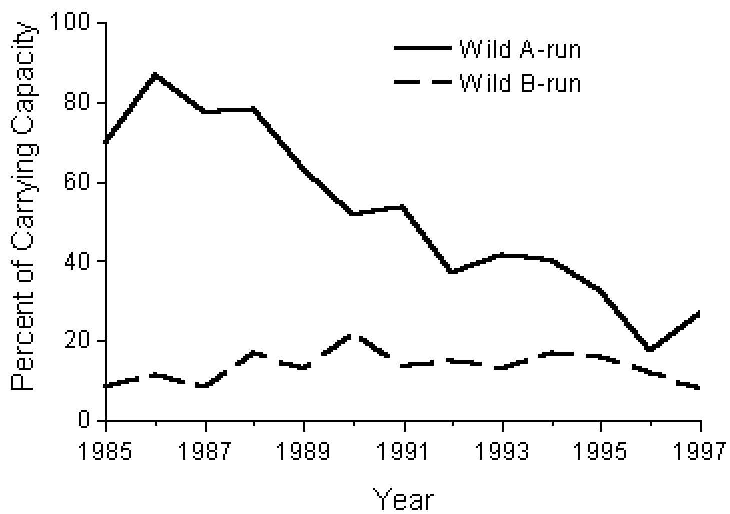


Data for the Lochsa exclude Fish Creek and Crooked Fork.

Sources: memo from T. Holubetz (IDFG), “1997 Steelhead Redd Counts”, dated May 16, 1997, and IDFG, unpubl. data).

Idaho has also conducted surveys for juvenile abundance in index areas throughout the Snake River basin since 1985. Parr densities of A-run steelhead have declined from an average of about 75% of carrying capacity in 1985 to an average of about 35% in recent years through 1995 (Figure A-5). Further declines were observed in 1996 and 1997. Parr densities of B-run steelhead have been low, but relatively stable since 1985, averaging 10% to 15% of carrying capacity through 1995. Parr densities in B-run tributaries declined further in 1996 and 1997 to 11% and 8%, respectively.

Figure A-5. Percent of Estimated Carrying Capacity for Juvenile (Age-1+ and -2+) Wild A- and B-Run Steelhead in Idaho Streams



Source: Data for 1985 through 1996 from Hall-Griswold and Petrosky (1998); data for 1997 from IDFG (unpublished).

It is apparent from the available data that B-run steelhead are much more depressed than the A-run component. In evaluating the status of the Snake basin steelhead ESU it is pertinent to consider whether B-run steelhead represent a significant portion of the ESU. This is particularly relevant because the Tribes have proposed to manage the SR basin steelhead ESU as a whole without distinguishing between components and further that it is inconsistent with NMFS authority to manage for components of an ESU.

It is first relevant to put the Snake River basin into context. The Snake River historically supported over 55% of total natural-origin production of steelhead in the Columbia basin and now has approximately 63% of the basin's natural production potential (Mealy 1997). B-run steelhead occupy four major subbasins including two on the Clearwater River (Lochsa and Selway) and two on the Salmon River (Middle Fork and South Fork Salmon), areas that for the most part are not occupied by A-run steelhead. Some natural B-run steelhead are also produced in parts of the mainstem Clearwater and its major tributaries. There are alternative escapement objectives for B-run steelhead of 10,000 (CRFMP) and 31,400 (Idaho). B-run steelhead therefore represent at least 1/3 and as much as 3/5 of the production capacity of the ESU.

B-run steelhead are distinguished from the A-run component by their unique life history characteristics. B-run steelhead were traditionally distinguished as larger and older, later-timed fish that return primarily to the South Fork Salmon, Middle Fork Salmon, Selway, and Lochsa rivers. The recent review by TAC concluded that different populations of steelhead do have different size structures, with populations dominated by larger fish (i.e., greater than 77.5 cm) occurring in the traditionally defined B-run basins (TAC 1999). Larger fish occur in other populations throughout the basin, but at much lower rates (evidence suggests that fish returning to the Middle Fork Salmon and Little Salmon are intermediate in that they have a more equal distribution of large and small fish).

B-run steelhead are also generally older. A-run steelhead are predominately age-1-ocean fish whereas most B-run steelhead generally spend 2 or more years in the ocean prior to spawning. The differences in ocean age are primarily responsible for the differences in the size of A- and B-run steelhead. However, B-run steelhead are also thought to be larger at age than A-run fish. This may be due, at least in part, to the fact that B-run steelhead leave the ocean later in the year than A-run steelhead and thus have an extra month or more of ocean residence at a time when growth rates are thought to be greatest.

Historically, a distinctly bimodal pattern of freshwater entry could be used to distinguish A-run and B-run fish. A-run steelhead were presumed to cross Bonneville Dam from June to late August whereas B-run steelhead enter from late August to October. TAC reviewed the available information on timing and confirmed that the majority of large fish do still have a later timing at Bonneville; 70% of the larger fish crossed the dam after August 26, the traditional cutoff date for separating A- and B-run fish (TAC 1999). However, the timing of the early part of the A-run has shifted somewhat later, thereby reducing the timing separation that was so apparent in the 1960s and 1970s. The timing of the larger, natural-origin B-run fish has not changed.

As pointed out above, the geographic distribution of B-run steelhead is restricted to particular watersheds within the Snake River basin (areas of the mainstem Clearwater, Selway, and Lochsa rivers and the South and Middle Forks of the Salmon River). No recent genetic data are available for steelhead populations in South and Middle Forks of the Salmon River. The Dworshak National Fish Hatchery (NFH) stock and natural populations in the Selway and Lochsa rivers are thus far the most genetically distinct populations of steelhead in the Snake River basin (Waples et al. 1993). In addition, the Selway and Lochsa River populations from the Middle Fork Clearwater appear to be very similar to each other genetically, and naturally produced rainbow trout from the North Fork Clearwater River (above Dworshak Reservoir) clearly show an ancestral genetic similarity to Dworshak NFH steelhead. The existing genetic data, the restricted geographic distribution of B-run steelhead in the Snake (Columbia) River basin, and the unique life history attributes of these fish (i.e. larger, older adults with a later distribution of run timing compared to A-run steelhead in other portions of the Columbia River basin) clearly support the conservation of B-run steelhead as a biologically significant component of the SR ESU.

Another approach to assessing the status of an ESU being developed by NMFS is to consider the status of its component populations. For this purpose a population is defined as a group of fish of the same species spawning in a particular lake or stream (or portion thereof) at a particular season, which to a substantial degree do not interbreed with fish from any other group spawning in a different place or in the same place at a different season. Because populations as defined here are relatively isolated, it is biologically meaningful to evaluate the risk of extinction of one population independently from any other. Some ESUs may be comprised of only one population whereas others will be constituted by many. The background and guidelines related to the assessment of the status of populations is described in a recent draft report discussing the concept of Viable Salmonid Populations (McElhany et al. 2000).

The task of identifying populations within an ESU will require making judgements based on the available information. Information regarding the geography, ecology, and genetics of the ESU are relevant to this determination. Although NMFS has not compiled and formally reviewed all the available information for this purpose, it is reasonable to conclude that, at a minimum, each of the major subbasins in the ESU represent a population within the context of this discussion. A-run populations would therefore include at least the tributaries to the lower Clearwater, the upper Salmon River and its tributaries, the lower Salmon River and its tributaries, the Grand Ronde, Imnaha, and possibly the Snake mainstem tributaries below Hells Canyon Dam. B-run populations would be identified in the Middle Fork and South Fork Salmon rivers and the Lochsa and Selway rivers (major tributaries of the upper Clearwater), and possibly in the mainstem Clearwater River, as well. These basins are, for the most part, large geographical areas and it is quite possible that there is additional population structure within at least some of these basins. However, because that hypothesis has not been confirmed, NMFS assumes that there are at least five populations of A-run steelhead and five populations of B-run steelhead in the Snake River basin ESU. Escapement objectives for A and B-run production areas in Idaho, based on estimates of smolt production capacity, are shown in Table A-13.

Table A-13. Adult Steelhead Escapement Objectives Based on Estimates of 70% Smolt Production Capacity

A-Run Production Areas		B-Run Production Areas	
Upper Salmon	13,570	Mid Fork Salmon	9,800
Lower Salmon	6,300	South Fork Salmon	5,100
Clearwater	2,100	Lochsa	5,000
Grand Ronde	(1)	Selway	7,500
Imnaha	(1)	Clearwater	4,000
Total	**21,970**	**Total**	**31,400**

Note: comparable estimates are not available for populations in Oregon and Washington subbasins.

Hatchery populations, if genetically similar to their natural-origin counterparts, provide a hedge against extinction of the ESU or of the gene pool. The Imnaha and Oxbow hatcheries produce A-run stocks that are currently included in the SR basin steelhead ESU. The Pahsimeroi and Wallowa hatchery stocks may also be appropriate and available for use in developing supplementation programs; NMFS required in its recent biological opinion on Columbia basin hatchery operations that this program begin to transition to a local-origin broodstock to provide a source for future supplementation efforts in the lower Salmon River (NMFS 1999b). Although other stocks provide more immediate opportunities to initiate supplementation programs within some subbasins, it may also be necessary and desirable to develop additional broodstocks that can be used for supplementation in other natural production areas. Despite uncertainties related to the likelihood that supplementation programs can accelerate the recovery of naturally spawning populations, these hatchery stocks provide a safeguard against the further decline of natural-origin populations.

The Dworshak NFH is unique in the Snake River basin in producing a B-run hatchery stock. The Dworshak stock was developed from natural-origin steelhead from within the North Fork Clearwater River, is largely free of introductions from other areas, and was therefore included in the ESU although not as part of the listed population. However, past hatchery practices and possibly changes inflow and temperature conditions related to Dworshak Dam have led to substantial divergence in spawn timing of the hatchery stock compared to what was observed historically in the North Fork Clearwater River and compared to natural-origin populations in other parts of the Clearwater basin. Because the spawn timing of the hatchery stock is much earlier than it was historically (Figure A-6), the success of supplementation efforts using these stocks may be limited. In fact, past supplementation efforts in the South Fork Clearwater River using Dworshak NFH stock have been largely unsuccessful, although improvements in out-planting practices have the potential to yield different results. In addition, the unique genetic character of Dworshak Hatchery steelhead noted above will limit the degree to which the stock can be used for supplementation in other parts of the Clearwater subbasin and particularly in the Salmon River B-run basins. Supplementation efforts in those areas, if undertaken, will more likely have to rely on the future development of local broodstocks. Supplementation opportunities in many of the B-run production areas will be limited in any case because of logistical difficulties in getting to and working in these high mountain wilderness areas. Because opportunities to accelerate the recovery of B-run steelhead through supplementation, even if successful, are expected to be limited, it is essential to maximize the escapement of natural-origin steelhead in the near term.

Finally, the conclusions and recommendations of the TAC's All Species Review are pertinent to this review of the status of Snake River steelhead. Considering information available through 1996, the 1997 All Species Review stated:

> Regardless of assessment methods for A and B steelhead, it is apparent that the primary goal of enhancing the upriver summer steelhead run is not being achieved. The status of upriver summer steelhead, particularly natural-origin fish, has become a serious concern. Recent declines in all stocks, across all measures of abundance, are disturbing.

There has been no progress toward rebuilding upriver runs since 1987. Throughout the Columbia River basin, dam counts, weir counts, spawning surveys, and rearing densities indicate natural-origin steelhead abundance is declining, culminating in the proposed listing of upriver stocks in 1996. Escapements have reached critically low levels despite the relatively high productivity of natural and hatchery rearing environments. Improved flows and ocean conditions should increase smolt-adult survival rates for upriver summer steelhead. However, reduced returns in recent years are likely to produce fewer progeny and lead to continued low abundance.

Although steelhead escapements would have increased (in some years substantially) in the absence of mainstem fisheries, data analyzed by the TAC indicate that effects other than mainstem Columbia River fishery harvest are primarily responsible for the currently depressed status and the long term health and productivity of wild steelhead populations in the Columbia River.

Though harvest is not the primary cause of declining summer steelhead stocks, and harvest rates have been below guidelines, harvest has further reduced escapements. Prior to 1990, the aggregate of upriver summer steelhead in the mainstem Columbia River appears at times to have led to the failure to achieve escapement goals at Lower Granite Dam. Wild Group B steelhead are presently more sensitive to harvest than other salmon stocks, including the rest of the steelhead run, due to their depressed status and because they are caught at higher rates in the Zone 6 fishery.

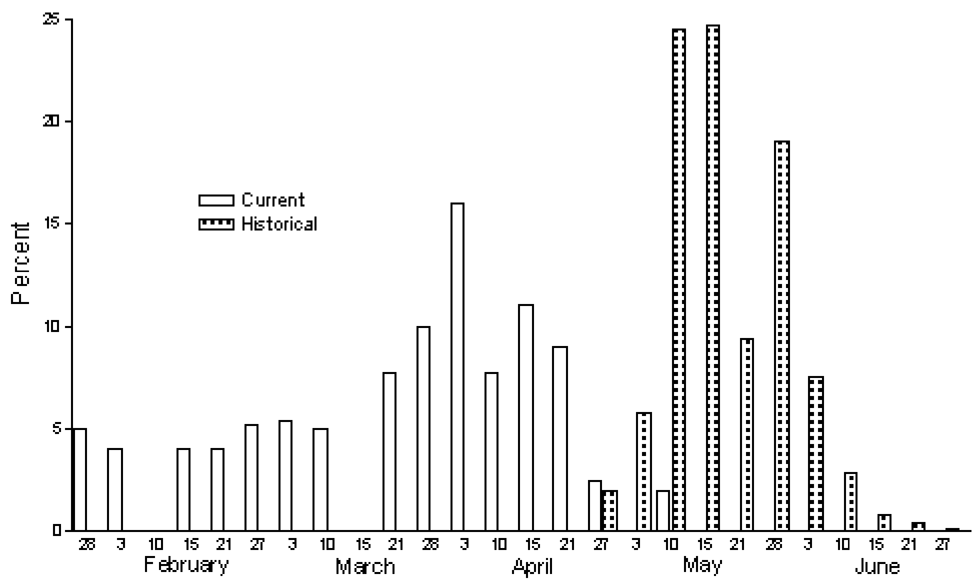
Small or isolated populations are much more susceptible to stochastic events such as drought and poor ocean conditions. Harvest can further increase the susceptibility of such populations. The CRFMP recognizes that harvest management must be responsive to run size and escapement needs to protect these populations. The parties should ensure that CRFMP harvest guidelines are sufficiently protective of weak stocks and hatchery broodstock requirements.

The All Species Review included the following recommendations:

- Develop alternative harvest strategies to better achieve rebuilding and allocation objectives.

- Consider modification of steelhead harvest rate guidelines relative to stock management units and escapement needs.

Figure A-6. Historical Versus Current Spawn-Timing of Steelhead at Dworshak Hatchery



For the SR steelhead ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period ranges from 0.90 to 0.18, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated the risk of absolute extinction within 24 and 100 years for the A and B runs, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from 0.12 for A-run steelhead to 0.35 for B-run fish (Table A6-a). At the high end, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 for both runs (Table A-6d).

NMFS has also calculated the proportional increase in the average growth rate of each run that would be needed to reduce the risk of absolute extinction within 100 years to 5% (Tables A-6a through A-6d; Appendix B in McClure et al. 2000). Assuming that the effectiveness of hatchery fish has been zero, the needed change in the growth rate of the wild population ranges from 0.01 for A-run steelhead to 0.02 for the B run (Table A-6a). The maximum needed change in growth rate rises as high as 470% for B-run steelhead if hatchery-origin spawners have been 100% as effective as wild fish (Table A-6d).

A.4.2.2 Upper Columbia River Steelhead

UCR steelhead inhabit the Columbia River reach and its tributaries upstream of the Yakima River. This region includes several rivers that drain the east slopes of the Cascades Mountains and several that originate in Canada (only U.S. populations are included in the ESU). Dry habitat conditions in this area are less conducive to steelhead survival than in many other parts of the Columbia basin (Mullan et al. 1992a). Although the life history of this ESU is similar to that of other inland steelhead, smolt ages are some of the oldest on the west coast (up to 7 years old), probably due to the ubiquitous cold water temperatures (Mullan et al. 1992b). Adults spawn later than in most downstream populations, remaining in freshwater up to a year before spawning.

Although runs during the period 1933 through 1959 may have already been affected by fisheries in the lower river, dam counts suggest a pre-fishery run size of more than 5,000 adults above Rock Island Dam. The return of UCR natural-origin steelhead to Priest Rapids Dam declined from a 5-year average of 2,700 beginning in 1986 to a 5-year average of 900 beginning in 1994 (FPC 1998; Table A-14). The escapement goal for natural-origin fish is 4,500. Most current natural production occurs in the Wenatchee and Methow River system, with a smaller run returning to the Entiat River. Very limited spawning also occurs in the Okanagan River basin. A majority of the fish spawning in natural production areas are of hatchery origin. Indications are that natural populations in the Wenatchee, Methow, and Entiat rivers are not self-sustaining.

This entire ESU has been subjected to heavy hatchery influence; stocks became thoroughly mixed as a result of the Grand Coulee Maintenance Project, which began in the 1940s (Fish and Hanavan 1948, Mullan et al. 1992a). Recently, as part of the development of the Mid-Columbia Habitat Conservation Plan (HCP), it was determined that steelhead habitat within the range of the UCR ESU was overseeded, primarily due to the presence of Wells Hatchery fish in excess of those collected for broodstock. This would partially explain recent observations of low natural cohort replacement rates (0.3 for populations in the Wenatchee River and no greater than 0.25 for populations in the Entiat River; Bugert 1997). The problem of determining appropriate levels of hatchery output to prevent negative effects on natural production is a subject of analysis and review in the mid-Columbia Quantitative Analytical Report (Cooney 2000). In the meantime, given these uncertainties, efforts are underway to diversify broodstocks used for supplementation and to minimize the differences between hatchery and natural-origin fish (as well as other concerns associated with supplementation). The best use for the Wells Hatchery program in the recovery process is yet to be defined, and should be integrated with harvest activities and recovery measures to optimize the prospects for recovery of the species.

For the UCR steelhead ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period ranges from 0.90 to 0.29, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated the risk of absolute extinction for the aggregate UCR steelhead population, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years is 0.95 (Table A-6a). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years is 1.00 (Table A-6d).

NMFS has also calculated the proportional increase in the average growth rate of the aggregate population that would be needed to reduce the risk of absolute extinction within 100 years to 5% (Tables A-6a through A-6d; Appendix B in McClure et al. 2000). Assuming that the effectiveness of hatchery fish has been zero, a 7% increase would be needed in the growth rate of the wild population (Table A-6a). The needed change in growth rate rises to 225% if hatchery-origin spawners have been 100% as effective as wild fish (Table A-6d).

Similar results are shown in Tables A-8a and A-8b for the population growth rate needed for recovery of the aggregate UCR steelhead population. The sensitivity of the recovery metrics to different assumptions methods of projecting population trends into the future is shown in Tables A9a to A9b.

Due to data limitations, the QAR steelhead assessments were limited to two aggregate spawning groups – the Wenatchee/Entiat composite and the above-Wells populations. Wild production of steelhead above Wells Dam was assumed to be limited to the Methow system. Assuming a relative effectiveness of hatchery spawners of 1.0, the risk of absolute extinction within 100 years for UCR steelhead is 100% (Table A-6f). The QAR also assumed hatchery effectiveness values of 0.25 and 0.75. A hatchery effectiveness of 0.25 resulted in projected risks of extinction of 22% for the Wenatchee/Entiat and 28% for the Methow populations. At a hatchery effectiveness of 0.75, risks of 100% were projected for both populations.

The change in survival necessary to reduce extinction risks to less than 5% within 100 years ranged from 15% for the Methow population, assuming hatchery effectiveness 0.25, to 67% for the Wenatchee/Entiat population (Table A-10). Substantial improvements in survival are needed to meet recovery levels for both spawning populations. The estimated survival changes required to meet or exceed the interim Recovery Criteria established by the Upper Columbia River Steelhead and Spring Chinook Salmon Biological Requirements Committee ranged from 50% for the Wenatchee/Entiat population at a hatchery spawner effectiveness of 0.25 to 200% for the Methow population at an effectiveness of 0.75.

Table A-14. Adult Summer Steelhead Counts at Priest Rapids, Rock Island, Rocky Reach, and Wells Dams (FPC 1998)

	Priest Rapids		Rock Island	Rocky Reach	Wells
Year	Count	Wild Origin	Count	Count	Count
1977	9,812		9,925	7,416	5,382
1978	4,545		3,352	2,453	1,621
1979	8,409		7,420	4,896	3,695
1980	8,524		7,016	4,295	3,443
1981	9,004		7,565	5,524	4,096
1982	11,159		10,150	6,241	8,418
1983	31,809		29,666	19,698	19,525
1984	26,076		24,803	17,228	16,627
1985	34,701		31,995	22,690	19,757
1986	22,382	2,342	22,867	15,193	13,234
1987	14,265	4,058	12,706	7,172	5,195
1988	10,208	2,670	9,358	5,678	4,415
1989	10,667	2,685	9,351	6,119	4,608
1990	7,830	1,585	6,936	5,014	3,819
1991	14,027	2,799	11,018	7,741	7,715
1992	14,208	1,618	12,398	7,457	7,120
1993	5,455	890	4,591	2,815	2,400
1994	6,707	855	5,618	2,823	2,138
1995	4,373	993	4,070	1,719	946
1996	8,376	843	7,305	5,774	4,127
1997	8,948	785	7,726	7,726	4,107
1998	5,790	919	4,810	4,265	2,482

A.4.2.3 Middle Columbia River Steelhead

Life history information for MCR steelhead indicates that most smolt at 2 years of age and spend 1 to 2 years in salt water (i.e., 1-ocean and 2-ocean fish, respectively). After re-entering fresh water, they may remain up to a year prior to spawning (Howell et al. 1985). Within the ESU, the Klickitat River is unusual in that it produces both summer and winter steelhead, and the summer steelhead are dominated by 2-ocean steelhead (most other rivers in this region produce about equal numbers of both 1-and 2-ocean steelhead).

Escapement to the Yakima, Umatilla, and Deschutes subbasins have shown overall upward trends, although all tributary counts in the Deschutes River are downward and the Yakima River is recovering from extremely low abundance in the early 1980s. The John Day River probably represents the largest native, natural spawning stock in the ESU, and the combined spawner surveys for the John Day River have been declining at a rate of about 15% per year since 1985. However, estimates based on dam counts show an overall increase in steelhead abundance, with a relatively stable naturally-produced component. NMFS, in proposing this ESU for listing as threatened under the ESA, cited low returns to the Yakima River, poor abundance estimates for Klickitat River and Fifteenmile Creek winter steelhead, and an overall decline for naturally-producing stocks within the ESU.

Hatchery fish are widespread and stray to spawn naturally throughout the region. Recent estimates of the proportion of natural spawners of hatchery origin range from low (Yakima, Walla Walla, and John Day rivers) to moderate (Umatilla and Deschutes rivers). Most hatchery production in this ESU is derived primarily from within-basin stocks. One recent area of concern is the increase in the number of SR hatchery (and possibly wild) steelhead that stray and spawn naturally within the Deschutes River basin. Studies have been proposed to evaluate, hatchery programs within the Snake River basin that have shown high rates of straying into the Deschutes River and to make needed changes to minimize straying to rivers within the MCR steelhead ESU.

The ESU is in the intermontane region and includes some of the driest areas of the Pacific Northwest, generally receiving less than 40 cm of rainfall annually (Jackson 1993). Vegetation is of the shrub-steppe province, reflecting the dry climate and harsh temperature extremes. Factors contributing to the decline of MCR steelhead include agricultural practices, especially grazing and water diversions/withdrawals. In addition, hydrosystem development has affected the ESU through loss of habitat above tributary hydro projects and through mortalities associated with migration through the Columbia River hydrosystem.

For the MCR steelhead ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period ranges from 0.87 to 0.33, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated the risk of absolute extinction for four subbasin populations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the Deschutes and Yakima River summer runs to 1.00 for the Umatilla River summer run (Table A-6a). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years rises to 1.00 for the Deschutes River summer run as well (Table A-6d).

NMFS has also calculated the proportional increase in the average growth rate of each of the four subbasin populations that would be needed to reduce the risk of absolute extinction within 100 years to 5% (Tables A-6a through A-6d; Appendix B in McClure et al. 2000). Assuming that the effectiveness of hatchery fish has been zero, changes in population growth rates of less than 10 % would be needed in the growth rate of the wild population (Table A-6a). The needed change in growth rate rises to a maximum of 252% for the Deschutes River summer run if hatchery-origin spawners have been 100% as effective as wild fish (Table A-6d).

A.4.2.4 Upper Willamette River Steelhead

The UWR steelhead ESU occupies the Willamette River and its tributaries upstream of Willamette Falls. This is a late-migrating winter group, entering fresh water primarily during March and April (Howell et al. 1985). Only the late run is included in the ESU; the largest remaining population is in the Santiam River system. The North Santiam River hatchery stock (ODFW stock 21) is part of this ESU; listing of this hatchery stock was determined not to be warranted.

Steelhead in the UWR basin are heavily influenced by hatchery practices and introductions of non-native stocks, and native fish into areas not originally the home of steelhead. Fishways built at Willamette Falls in 1885, modified and rebuilt several times, have facilitated the introduction of Skamania-stock summer steelhead and early-migrating winter steelhead of Big Creek stock. Non-native production of summer steelhead appears quite low, and the summer population is almost entirely maintained by artificial production (Howell et al. 1985). Some naturally-reproducing returns of Big Creek-stock winter steelhead occur in the basin (primarily early stock; Table A-15). In recent years, releases of winter steelhead are primarily of native stock from the Santiam River system.

No estimates of abundance prior to the 1960s are available for this ESU. Recent run size can be estimated from redd counts, dam counts, and counts at Willamette Falls (late stock; Table A-15). Recent total-basin run size estimates exhibit general declines for winter steelhead. The majority of winter steelhead populations in this basin may not be self-sustaining.

Much of the Willamette River basin is urban or agricultural, and clearcut logging has been widespread in the Willamette River watershed. Water temperatures and streamflows reach critical levels in the basin, and channel modification and bank erosion is substantial. Artificial production practices are a major threat to this ESU. Introgression from non-local winter hatchery stocks may occur. Artificial selection of later run timing may also result from competition with substantial numbers of hatchery fish and from selective fishing pressures.

For the UWR steelhead ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period ranges from 0.91 to 0.66, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated the risk of absolute extinction for four subbasin populations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the South Santiam River to 1.00 for the Calipooia River (Table A-6a). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years rises to 1.00 for all four populations (Table A-6d).

NMFS has also calculated the proportional increase in the average growth rate of each of the four subbasin populations that would be needed to reduce the risk of absolute extinction within 100 years to 5% (Tables A-6a through A-6d; Appendix B in McClure et al. 2000). Assuming that the effectiveness of hatchery fish has been zero, changes of up to 26% (for the Calipooia River) would be needed in the growth rates of the wild populations (Table A-6a). The needed change in growth rate rises to a maximum of 88% for the Mollala River if hatchery-origin spawners have been 100% as effective as wild fish (Table A-6d).

Table A-15. Escapement of Winter Steelhead over Willamette Falls and over North Fork Dam on the Clackamas River, 1971 through 1998

	Willamette Falls Count			
Year[1]	Total	Early Stock[2]	Late Stock[3]	North Fork Dam
1971	26,647	8,152	18,495	4,352
1972	23,257	6,572	16,685	2,634
1973	17,900	6,389	11,511	1,899
1974	14,824	5,733	9,091	680
1975	6,130	3,096	3,034	1,509
1976	9,398	4,204	5,194	1,488
1977	13,604	5,327	8,277	1,525
1978	16,869	8,599	8,270	2,019
1979	8,726	2,861	5,865	1,517
1980	22,356	6,258	16,097	2,065
1981	16,666	7,662	9,004	2,700
1982	13,011	6,117	6,894	1,446
1983	9,298	4,596	4,702	1,099
1984	17,384	6,664	10,720	1,238
1985	20,592	4,549	16,043	1,225
1986	21,251	8,475	12,776	1,432
1987	16,765	8,543	8,222	1,318
1988	23,378	8,371	15,007	1,773
1989	9,572	4,211	5,361	1,251
1990	11,107	1,878	9,229	1,487
1991	4,943	2,221	2,722	837
1992	5,396	1,717	3,679	2,107
1993	3,568	843	2,725	1,352
1994	5,300	1,025	4,275	1,247
1995	4,693	1,991	2,702	1,146
1996	1,801	479	1,322	325
1997	4,544	619	3,925	530
1998	3,678	757	2,921	504

1 Represents year in which passage is completed. Passage began during the previous year. Total estimates of passage were not obtained prior to 1971 due to problems of access to the old fishway during higher flow periods.
2 November 1 through February 15. These are mainly introduced Big Creek stock.
3 February 16 through May 15. These are mainly indigenous Willamette stock.

A.4.2.5 Lower Columbia River Steelhead

Busby et al. (1996) summarize the available information on the historical and recent abundances LCR steelhead. No estimates of historical abundance (pre-1960s) specific to this ESU are available. Because of their limited distribution in upper tributaries and the urbanization surrounding the lower tributaries (e.g., the lower Willamette, Clackamas, and Sandy rivers run through Portland, Oregon, or its suburbs), summer steelhead appear to be more at risk from habitat degradation than winter steelhead. Based on angler surveys during a limited period, populations in the lower Willamette, Clackamas, and Sandy rivers appear to be stable or increasing slightly, but this type of data may not reflect trends in underlying abundances. Total annual run size is only available for the Clackamas River population (1,300 winter steelhead, 70% hatchery; 3,500 summer steelhead).

Population dynamics indicate that the Oregon component of the LCR steelhead ESU is at risk such that the capacity to survive future periods of environmental stress is unacceptably low (Chilcote 1998). The recent collapse of winter steelhead in the Clackamas River, and the status of summer steelhead in the Hood River (which together comprise 33% of the ESU) are of special concern. The Kalama River population is the only one in Washington State considered “healthy” (WDFW 1997). All of the other winter steelhead populations (i.e., those in the Cowlitz, Coweeman, North Fork and South Fork Toutle, Green, North Fork Lewis, and Washougal rivers) are considered “depressed” (WDFW 1997). The status of populations of winter steelhead in Hamilton Creek and the Wind River are unknown. The WDFW trapped fish at Shiperd Falls on the Wind River during winter 1999-2000 and will use these data to develop preliminary estimates of steelhead abundance. Among summer steelhead, populations from the Kalama River, North and East Forks of the Lewis River, and the Washougal River are considered depressed and the Wind River stock is classified as “critical” (WDFW 1997).

Recent estimates of the proportion of hatchery fish on the winter-run steelhead spawning grounds are more than 80% in the Hood and Cowlitz rivers, 45% in the Sandy, Clackamas, and Kalama rivers, and approximately 75% for summer-run steelhead in the Kalama River. Only three out of 14 populations for which data are available are estimated to have low percent hatchery fish (0% of the Washougal River summer run and of the runs in Panther and Trout creeks in the Wind River basin). NMFS is unable to identify any natural populations of steelhead in this ESU that could be considered “healthy”, especially in light of new genetic data from WDFW that indicate some introgression between the Puget Sound Chambers Creek Hatchery stock and wild steelhead in this ESU (Phelps et al. 1997). In addition, summer steelhead, native to the Hood, Lewis, Washougal and Kalama rivers, have been introduced into the Sandy and Clackamas rivers. Naturally-spawning populations of winter steelhead appear to have been negatively affected by these introductions, probably through interbreeding and competition (Chilcote 1998).

For the LCR steelhead ESU as a whole, NMFS estimates that the average population growth rate (lambda) over the base period ranges from 0.98 to 0.36, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Table A-5a through A-5d; Appendix B in McClure et al. 2000). NMFS has also estimated the risk of absolute extinction for seven of the subbasin populations, using the same range of assumptions about the relative effectiveness of hatchery fish. At the low end, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0), the risk of absolute extinction within 100 years ranges from zero for the Kalama River summer run and the Clackamas and Kalama River winter runs to 1.00 for the Clackamas River summer run and the Toutle River winter run (Table A-6a). Assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%), the risk of absolute extinction within 100 years rises to 1.00 for all but one population (the risk of extinction is 0.94 for the Green River winter run; Table A-6d).

NMFS has also calculated the proportional increase in the average growth rate of each of the seven subbasin populations that would be needed to reduce the risk of absolute extinction within 100 years to 5% (Tables A-6a through A-6d; Appendix B in McClure et al. 2000). Assuming that the effectiveness of hatchery fish has been zero, changes in population growth rates of less than 20% would be needed for each of the wild populations (Table A-6a). The needed change in growth rate rises to a maximum of 304%, for the Kalama River summer run, if hatchery-origin spawners have been 100% as effective as wild fish (Table A-6d).

A.5 CHUM SALMON

A.5.1 Columbia River Chum Salmon

The Columbia River historically contained large runs of chum salmon that supported a substantial commercial fishery in the first half of this century. These landings represented an annual harvest of more than 500,000 chum salmon as recently as 1942. Beginning in the mid-1950s, commercial catches declined drastically and in later years rarely exceeded 2,000 per year. Annual catch, as incidental take in the late fall mainstem Columbia River fishery, has been less than 50 fish since 1994.

Fulton (1970) reported that chum salmon used 22 of 25 historical spawning areas in the lower Columbia River below The Dalles Dam. Even at the time of publication, access to suitable tributary habitat was limited by natural (falls, heavy rubble, and boulders) and manmade structures (dams and water diversions). Habitat quality was limited by siltation where watersheds had been subjected to heavy logging. Currently, spawning is limited to tributaries below Bonneville Dam, with most spawning in two areas on the Washington side of the Columbia River: Grays River, near the mouth of the Columbia River, and Hardy and Hamilton creeks, approximately 3 miles below Bonneville Dam. Some chum salmon pass Bonneville Dam, but there are no known extant spawning areas in Bonneville pool. Grays River chum salmon enter the Columbia River from mid-October to mid-November, but do not reach the Grays River until late October to early December. These fish spawn from early November to late December. Fish returning to Hamilton and Hardy Creeks begin to appear in the Columbia River earlier than Grays River fish (late September to late October) and have a more protracted spawn timing (mid-November to mid-January).

The estimated minimum run size for the CR ESU has been relatively stable, albeit at a very low level, since the run collapsed during the mid-1950s (Figure A-7). Current abundance is probably less than 1% of historical levels and the ESU has undoubtedly lost some (perhaps much) of its original genetic diversity. Average annual natural escapement to the index spawning areas was approximately 1,300 fish for the period 1990 through 1998 (ODFW and WDFW 1999).

Index spawning areas are located in the Grays River system, near the mouth of the Columbia River, and in the Hardy Creek/Hamilton Creek/Ives Island complex below Bonneville Dam. The WDFW surveyed other (non-index) areas in 1998 and found only small numbers of chum salmon (typically less than 10 fish per stream) in Elochoman, Abernathy, Germany, St. Cloud, and Tanner creeks and in the North Fork Lewis and the Washougal rivers. The State of Oregon does not conduct targeted surveys so the current extent of chum salmon spawning on the Oregon side of the river is unknown. Kostow (1995) cited reports of 23 spawning areas in Oregon tributaries but these are based on incidental observations (pers. comm., K. Kostow, Fisheries Biologist, ODFW, Portland, Oregon, August 6, 1999).

In the Grays system, chum salmon spawn in the mainstem from approximately one-half mile upstream of the West Fork downstream to the Covered Bridge, a distance of approximately 4 miles (WDF et al. 1992). Tributary spawning occurs in the West Fork, Crazy Johnson, and Gorely creeks. The historical influence of hatchery fish in the Grays system is small compared to other ESUs. Hatchery-cultured chum salmon from Willapa Bay (i.e., Pacific Coast chum salmon ESU) were transplanted into the Chinook River (a tributary to Baker Bay in the Columbia River estuary) during the late 1980s. Initial returns from this transplant were close to a thousand fish per year and recent returns were substantially lower (less than or equal to 20 fish per year during 1997 and 1998). In 1998, WDFW decided that non-native chum should be removed from the system and consequently, all Willapa Bay chum salmon returning to the Sea Resources Hatchery during 1999 were destroyed. The Sea Resources and Grays River hatcheries are now used to culture Columbia River chum salmon (collected from Gorley Creek) for reintroduction into the Chinook River. Overall, the abundance of the Grays River population has increased since the mid-1980s but appears to follow a cyclical pattern (McClure et al. 2000). The population rate of growth is positive but the cyclical trend results in a high variability around the average estimate.

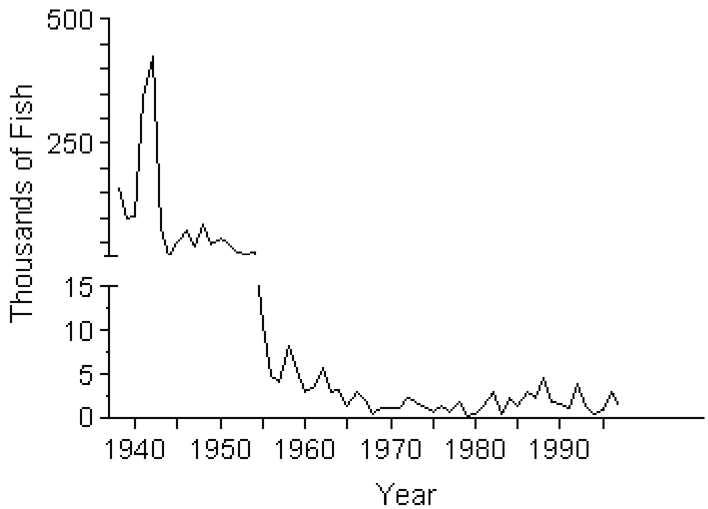
The Hardy and Hamilton creeks/Ives Island complex is located approximately 2.0 miles below Bonneville Dam. Hamilton Slough once separated Hamilton Island from the Washington State shoreline. Sometime before 1978, a dike was built across the slough, separating its upstream and downstream ends (Corps 1978). The waterway that now appears to be the lower end of Hamilton Creek is actually the downstream end of the former slough; the mouth of Hamilton Creek proper adjoins the remnant slough at its northern terminus. These large-scale landscape modifications are likely to have changed the hydraulics of the Hamilton Slough/Ives Island spawning area.

Escapements to Hamilton Creek have averaged less than 100 fish in recent years. The WDFW recently completed a major habitat development project in Hamilton Springs, a spring-fed tributary to Hamilton Creek. Chum salmon escapement to Hamilton Springs averaged 170 during the last 3 years (1997 through 1999; Figure A-8). Hardy Creek is located just downstream of Hamilton Creek. Annual escapements have ranged from 22 to 1,153 spawners over the last 10 years with a generally increasing trend. Hardy Creek is now incorporated into the Pierce National Wildlife Refuge and chum salmon have benefitted from recent (and ongoing) habitat improvement programs (a vehicle bridge over Hardy Creek, cattle fencing, development of additional spawning gravels).

The current upstream extent of spawning by CR chum salmon, and thus the effect of Bonneville Dam as a barrier to migration, is unknown. Adult chum salmon are commonly thought to show little persistence in surmounting river blockages and falls (63 FR 11775). The 10-year average (1989 through 1998) count for the fish ladders at Bonneville Dam was 56 adults (Table A-16), although this statistic is heavily skewed by a count of 195 chum salmon in 1998 (J. Loch, WDFW, unpubl. data). The unusually high count was due to (1) an increase in the effort applied to interrogating the video tapes for observations of chum salmon and (2) unusually high activity in the fish ladders at night, possibly related to unusual temperature conditions in Bonneville pool (pers. comm., J. Loch, WDFW, January 28, 2000). Without the 1998 data, the nine-year average would be only 31 adult chum. NMFS considers these data on chum salmon passage at Bonneville Dam extremely important given the implications for spawning in Bonneville pool (i.e., and for reservoir operations that may affect spawning habitat once these areas are identified).

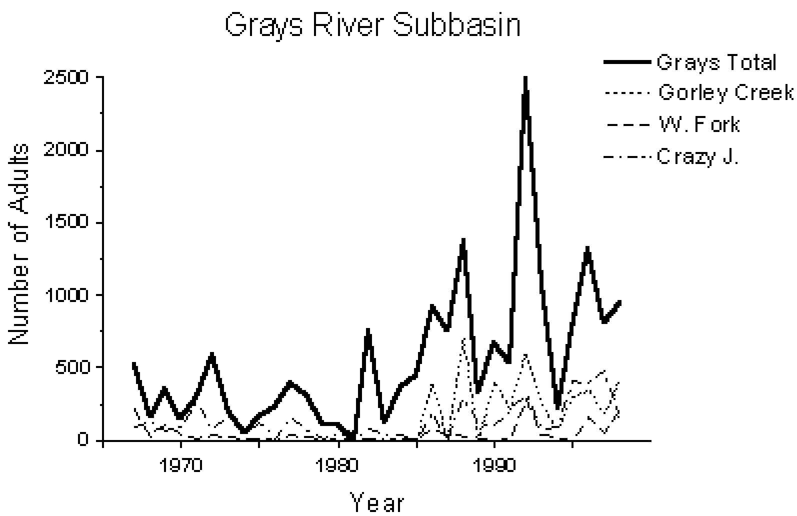
Hatchery fish have had little influence on the wild component of the CR chum salmon ESU. NMFS estimates an average population growth rate (lambda) over the base period, for the ESU as a whole, of 1.03 (Table A-5a through A-5d; Appendix B in McClure et al. 2000). Because census data are peak counts (and because the precision of these counts decreases markedly during the spawning season as water levels and turbidity rise), NMFS is unable to estimate the risk of absolute extinction for this ESU.

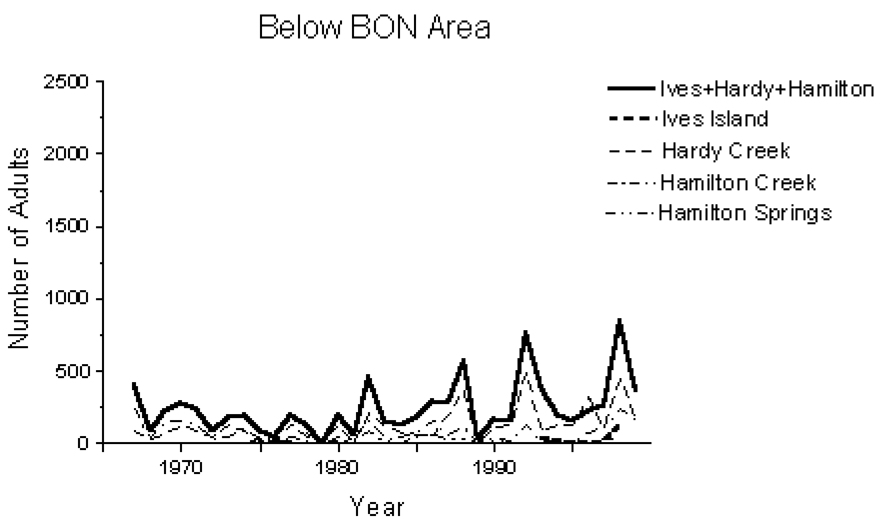
Figure A-7. Minimum Run Size for Columbia River Chum Salmon, 1938 to 1998



Note: These values were calculated by summing harvest, spawner surveys, and Bonneville Dam counts. Data from ODFW and WDFW (1999).

Figure A-8. Peak Counts of Adult Chum in Index Spawning Areas, 1967 through 1999





Source: WDFW, unpublished data

Table A-16. Chum Salmon Counted in the Bonneville Dam Adult Fish Ladders (1989 through 1998)

Year	Total Number
1989 [1]	16
1990 [1]	26
1991 [1]	5
1992 [2]	39
1993 [2]	51
1994 [2]	26
1995 [2]	30
1996 [2]	33
1997 [3]	50
1998 [4]	195

Source: J. Loch, WDFW, unpubl. data. The following footnotes were provided by J. Loch:

1 Only daytime videos available for November 1989 through 1991 (8 a.m. - 4 p.m.).

2 Wild steelhead were the target species recorded from nighttime video tapes by WDFW readers. Non-target species (e.g., chum salmon) were not always recorded.

3 Wild steelhead were again the target species but some non-target species may have been recorded. Note: data for non-target species were not included in the Corps' Annual Fish Passage reports.

4 1998 was the first year that the Corps contracted with the WDFW counting program to read videotapes for all salmonids. Although wild steelhead remained the target species for the video count program, observations of chums salmon, pink salmon, and chinook salmon were also tallied by the video reader. All counts were included in the Corps' annual report.

A.6 SOCKEYE SALMON

A.6.1 Snake River Sockeye Salmon

Historically, Snake River sockeye salmon were produced in the Salmon River subbasin in Alturas, Pettit, Redfish, and Stanley lakes, and in the South Fork Salmon River subbasin in Warm Lake. Sockeye salmon may have been present in one or two other Stanley basin lakes (Bjornn et al. 1968). Elsewhere in the Snake River basin, sockeye salmon were produced in Big Payette Lake on the North Fork Payette River and in Wallowa Lake on the Wallowa River (Evermann 1895, Toner 1960, Bjornn et al. 1968, Fulton 1970).

The largest single sockeye salmon spawning area was in the headwaters of the Payette River, where 75,000 were taken one year by a single fishing operation in Big Payette Lake. However, access to production areas in the Payette basin was eliminated by construction of Black Canyon Dam in 1924. During the 1980s, returns to headwaters of the Grand Ronde River in Oregon (Wallowa Lake) were estimated to have been at least 24,000 and 30,000 sockeye salmon (Cramer 1990), but access to the Grand Ronde was eliminated by construction of a dam on the outlet to Wallowa Lake in 1929. Access to spawning areas in the upper Snake River basin was eliminated in 1967 when fish were no longer trapped and transported around the Hells Canyon Dam complex. All of these dams were constructed without fish passage facilities.

There are no reliable estimates of the number of sockeye salmon spawning in Redfish Lake at the turn of the century. However, beginning in 1910, access to all lakes in the Stanley basin was seriously reduced by the construction of Sunbeam Dam, 20 miles downstream from Redfish Lake Creek on the mainstem Salmon River. The original adult fishway, constructed of wood, was ineffective at passing fish over the dam (Kendall 1912). It was replaced with a concrete structure in 1920 but sockeye salmon access was impeded until the dam was partially removed in 1934. Even after fish passage was restored at Sunbeam Dam, sockeye salmon were unable to use spawning areas in two of the lakes in the Stanley basin. Welsh (1991) reported fish eradication projects in Pettit Lake (treated with toxaphene in 1960) and Stanley Lake (treated with Fish-Tox, a mixture of rotenone and toxaphene, in 1954). Agricultural water diversions cut off access to most of the lakes. Bjornn et al. (1968) stated that, during the 1950s and 1960s, Redfish Lake was probably the only lake in Idaho that was still used by sockeye salmon each year for spawning and rearing and, at the time of listing under the ESA, sockeye salmon were produced naturally only in Redfish Lake.

Escapement to the Snake River declined dramatically in the last several decades. Adult counts at Ice Harbor Dam declined from 3,170 in 1965 to zero in 1990 (ODFW and WDFW 1998). The Idaho Department of Fish and Game counted adults at a weir in Redfish Lake Creek during 1954 through 1966; adult counts dropped from 4,361 in 1955 to fewer than 500 after 1957 (Bjornn et al. 1968). A total of 16 wild sockeye salmon returned to Redfish Lake between 1991 and 1999 (Table A-17). An additional seven adults returned to the Sawtooth Hatchery during 1999; fin clips identified these adults as second generation progeny of eight wild fish that returned to Redfish Lake in 1993, were captured, and were brought into a captive broodstock program. These were the first expected returns. Progeny from the same release group (May 1998, into the Salmon River below the Sawtooth Hatchery) are expected to return through 2003.

The Snake River sockeye population currently consists of less than 10 adults. Although numbers are inadequate for a CRI-type risk of extinction analysis, clearly the risk is very high.

Table A-17. Returns of Snake River Sockeye Salmon to Lower Granite Dam and to Redfish Lake

Year	LGR Dam Count	Adults at Redfish Lake
1985	35	12
1986	15	29
1987	29	16
1988	23	4
1989	2	1
1990	0	0
1991	8	4
1992	1	1
1993	12	8
1994	2	1
1995	4	0
1996	0	1
1997	2	0
1998	3	1
1999	*16*	*7*

Returns were determined by dam count, trapping at Redfish Lake creek weir, and spawning ground surveys. Numbers in italics (1999) represent fin-clipped adults, returning as progeny from the captive broodstock program.

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