

Chapter 6 — Limiting Factors and Threats to Recovery

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6 Limiting Factors and Threats to Recovery

Chapter 6 presents Oregon's Upper Willamette River Recovery Planning Team's findings regarding limiting factors and threats to the recovery of the Upper Willamette River Chinook and steelhead ESUs. The chapter consists of three parts. Section 6.1 provides an overview of the process used to develop Oregon's list of key and secondary limiting factors and threats to the recovery of Upper Willamette River Chinook and steelhead. Section 6.2 describes Oregon's findings regarding limiting factors and threats for each species and population at all life cycle stages. Section 6.3 provides a list of planning team members, as well as a bibliography of the background material that the Expert Panel used to identify and rate limiting factors and threats.

6.1 Mandates Guiding Plan Development

The Planning Team identified key and secondary limiting factors and threats to the recovery of Oregon's Upper Willamette River Chinook and steelhead populations through a sequential process that included broad technical, policy-level and stakeholder involvement. The Clackamas River Chinook population, although classified as a component of the Upper Willamette River ESU, is not discussed here because it is being incorporated in recovery planning for the Oregon portion of the Lower Columbia River.

6.1.1 Introduction

The Planning Teams formal findings regarding limiting factors and threats (referred to as LF/T) for Oregon's Upper Willamette basin populations provide the basis for identifying management actions that will, if implemented, contribute to improving viability of each population. These findings were identified through the following sequential process:

1. An Expert Panel Process established a foundation for Oregon's LF/T determinations by proposing a set of key and secondary limiting factors and threats for these populations. The Panel, created by the Oregon Department of Fish and Wildlife for this purpose, consisted of -- biologists with significant knowledge of the limiting factors and threats influencing Upper Willamette River Chinook and steelhead recovery. Panelists identified limiting factors and threats for each of the independent populations, and common key and secondary threat themes for all of the populations.
2. The findings of the Expert Panel were reviewed by Planning Team members and then modified by the Planning Team by consensus.
3. LF/T initially identified in the estuary by the Expert Panel were updated based on information provided in NOAA Fisheries Service's Estuary Module (NOAA Fisheries Service Review Draft July 05, 2005).
4. A draft of this chapter of the recovery plan was reviewed for accuracy by Planning and Stakeholder Teams.
5. The Planning Team made final revisions to the LF/T presented here.

Oregon's findings regarding LF/Ts for Upper Willamette River steelhead and Chinook do not identify differences in the relative magnitude of LF/T among the major threat categories (i.e. harvest, hatchery, hydro, land management, introduced species). Instead, the LF/T identified in this chapter represents the Planning Team's judgment of the significant LF/T throughout the life cycle of the Chinook and steelhead populations in the UW ESUs. Chapter 8, Recovery Scenarios and All-H Analysis, provides an analysis of the relative magnitude of impacts associated with each major threat category.

6.1.2 Life Stages and Geographic Areas Considered

Life Stage Definitions

Two different juvenile life stage characterizations were used depending on the spatial location of the LF/T. Juvenile life stages in tributaries are based on the concept that differences in seasonal habitat needs often require different actions to adequately address LF/T concerns. Juvenile life stages in the estuary and mainstem Columbia are based on a condensed version of the life history strategies used in the Estuary Module (LCREP 2004). The juvenile life history strategies in the Estuary Module and their relation to the condensed life history strategies used in this chapter are shown in Table 6-1.

Table 6-1. Six juvenile life history strategies defined in the Estuary Module (citation) and the analogous life history categories used in the analysis of limiting factors and threats to salmon and steelhead as they pass through the Columbia River estuary and mainstem.

Life History Strategy from Estuary Module	Attributes Defined in Estuary Module	Life History Strategy Category in this Plan
Early fry	Freshwater rearing: 0 - 60 days. Size at estuarine entry: <50 mm Time of estuarine entry: March - April Estuarine residence time: 0 - 40 days	Fry
Late fry	Freshwater rearing: 20 - 60 days. Size at estuarine entry: <60 mm Time of estuarine entry: May - June, present through Sept. Estuarine residence time: <50 days	
Early fingerling	Freshwater rearing: 60 - 120 days. Size at estuarine entry: 60 - 100 mm Time of estuarine entry: April - May Estuarine residence time: <50 days	Fingerling/subyearling
Late fingerling	Freshwater rearing: 50 - 180 days. Size at estuarine entry: 60 - 130 mm Time of estuarine entry: June - October, present through winter Estuarine residence time: 0 - 80 days	
Subyearling (smolt)	Freshwater rearing: 20 - 180 days. Size at estuarine entry: 70 - 130 mm Time of estuarine entry: April - October Estuarine residence time: <20 day	
Yearling	Freshwater rearing: >1 year. Size at estuarine entry: >100 mm Time of estuarine entry: February - May Estuarine residence time: <20 days	Yearling

Geographic Areas

Life-stage specific LF/T may occur within five distinct geographic areas that together encompass the entire lifecycle of Upper Willamette River Chinook and steelhead. These geographic areas and the specific life stages considered in this chapter are:

Tributaries – Streams and rivers within a specific population area (Life stages: eggs, alevin, fry, summer parr, winter parr, smolts, returning adults, spawners).

Mainstem Willamette – The mainstem Willamette River above Willamette Falls (Life stages: pre-smolts, smolts, returning adults).

West Side Tributaries – Streams on the west side of the Willamette River above Willamette Falls (Life stages: pre-smolts).

Estuary - Tidally influenced areas of the Columbia River below Bonneville Dam and the Willamette River below Willamette Falls including the Columbia River Plume (Life stages: pre-smolts, smolts, returning adults).

Ocean – Saltwater areas outside of the estuary (Life stages: sub-adults, adults).

6.1.3 General Limiting Factor Categories

Limiting factors are the physical, biological, or chemical conditions and associated ecological processes and interactions (e.g., population size, habitat connectivity, water quality, water quantity, etc.) experienced by the fish that may influence viable salmonid population (VSP) parameters (i.e. abundance, productivity, spatial structure, and diversity). The categories of limiting factors used in Oregon's LF/T assessment and their definitions are described below.

Hydrology/water quantity – Timing and magnitude of flows.

Water quality – Water characteristics including temperature, dissolved oxygen, suspended sediment, pH, toxics, etc.

Predation – Consumption of naturally produced fish by another species (does not include fishery mortality).

Competition – Adverse interaction between naturally produced fish and other fish or other species, both of which need some limited environmental factor (i.e. food or space).

Nutrients – This limiting factor is primarily directed toward the role of salmon carcasses.

Disease – Pathological condition in naturally produced fish resulting from infection.

Physical habitat quality – Quality or quantity of physical habitat. Examples include instream roughness, channel morphology, riparian conditions, fine sediment, etc.

Habitat access – Impaired access to spawning and/or rearing habitat. Examples include impassable culverts, delayed migration over dams, dewatered stream channels, etc. If, for example, a stream has been diked, thereby eliminating access to off-channel habitat, habitat access should be considered a problem. If off-channel habitat to which access has been eliminated is in impaired condition, it also is considered an element of the physical habitat quality/quantity limiting factor.

Population traits – Impaired population condition(s) including: genetic, life history,

morphological, productivity, fitness, behavioral characteristics, and population size. Population traits may be lost through such means as hatchery influences, harvest mortality and selection, and altered environmental conditions from human actions or natural occurrences. Although population traits are caused by other limiting factors, they may also and independently be a limiting factor.

6.1.4 General Threat Categories

Threats were described in relation to the limiting factor(s) primarily affected, life stage(s) primarily affected, and specific nature of the threat. Limiting factors and threats for each population are classified as either key or secondary to provide strategic guidance to recovery actions. Oregon's findings regarding LF/T include the concept of legacy threats; practices or events that occurred in the past (i.e., practices that do not occur today), initiating environmental conditions that continue to impact population viability. Conditions that currently limit viability of populations require remediation, regardless of the cause of those conditions. The categories of threats used in Oregon's LF/T assessment and their definitions are described below.

Threat: Fishery Harvest Management – Direct and indirect mortality associated with fisheries on naturally produced fish.

Harvest may affect salmonid population viability by affecting abundance, productivity, spatial structure and/or diversity. Upper Willamette River steelhead and Chinook may be caught in ocean, mainstem Columbia River (estuary), mainstem Willamette, or tributary fisheries depending on their distribution, run timing relative to fishery openings and vulnerability to gear. Because of their exposure to fisheries across large geographic regions of the West Coast, Pacific salmon and steelhead management is governed by a number of regional organizations. Fisheries of the Columbia River are established within the guidelines and constraints of the Pacific Salmon Treaty, the Columbia River Fish Management Plan, the Endangered Species Act administered by NOAA Fisheries, The Pacific Fishery Management Council, the states of Oregon and Washington, the Columbia River Compact, and management agreements negotiated between the parties to US v. Oregon.

Fisheries directed at the Upper Willamette River spring Chinook are currently managed by ODFW to protect and recover wild populations while also maximizing harvest of hatchery-reared spring Chinook. In 1997 efforts were first made to adipose fin-clip all hatchery juveniles released in the Upper Willamette River Chinook ESU. At the time of writing of the Fisheries Management and Evaluation Plan (FMEP) for Willamette River spring Chinook (ODFW 2001a), ODFW estimated that 85-95% of spring Chinook in the Upper Willamette basin were of hatchery origin. The FMEP limits total freshwater fishery impact on wild fish to 15%. Management under the FMEP began in 2001, and the regulation that only marked fish could be retained in fisheries managed under the FMEP began in 2002, the first year that almost all returning hatchery adults would have had such marks (except 6-year olds). This selective fishery was expected to result in a 75% reduction in average fishery mortality compared to 1981-1997.

Ocean fisheries affecting Upper Willamette River spring Chinook include Southeast Alaska and Canadian troll fisheries. Upper Willamette River spring Chinook return somewhat earlier than other Columbia basin spring Chinook stocks. Owing to their early run timing, numbers of Upper Willamette River spring Chinook taken in Oregon and Washington coastal sport and commercial fisheries are relatively low (ODFW 2001a). Adults begin to return to the Columbia River near the beginning of January, increasing to peak numbers in late March and tapering off by mid-May. Migration into the Willamette Basin normally begins in March, rises rapidly from mid-April to early May, and then drops off fairly steadily after mid May and is mostly complete by July. Migration upriver occurs throughout the late spring and summer and spawning occurs primarily in September and October. Various fisheries occur within the Lower Columbia River and Willamette River basin management area throughout the year (Table 6-3). Fisheries targeting spring Chinook mostly occur near the peak of return migration, following the fish up the Willamette basin from March through mid August.

Mortality of released fish in Columbia River spring Chinook sport fisheries (including the Lower Willamette) is estimated to be 10% (ODFW 2003). The Lower Willamette River sport fishery has historically had a very large impact on Upper Willamette River spring Chinook. Before 1997, impacts from this fishery alone on the total population (hatchery plus wild) were consistently greater than 15% (Table 6-3). An estimate for impacts on wild fish only was first made in 2000 (14.0%). In 2001-2003, however, estimated impacts of this fishery were much lower (2.1%, 3.0% and 2.4%). Impacts of several other freshwater fisheries are available for 2003 (Table 6-4), and for 1981-1997 (averages) and 1998-2003 separately (Table 6-4). Besides the sport fishery of the Lower Willamette, sport fisheries in the Clackamas and North Santiam have consistently had the highest impacts on Upper Willamette River Chinook. Mortality of released fish in Willamette Basin sport fisheries is estimated to be 12.2% (Lindsay et al. 2003). However, total estimated impacts were much lower in 2001-2003 than in the past in both the Clackamas (1.49%, 4.9% and 0.84%, respectively) and the North Santiam (2.5% in all three years) fisheries.

In 2001, total estimated impacts of all FMEP managed fisheries on wild Upper Willamette River Chinook was 12.26%. In 2002 and 2003, these total estimated impacts were, respectively, 15.13% and 9.24%. Thus, FMEP management in 2001 reduced estimated impacts below the allowable 15% level. Regulations allowing retention of only marked fish came very close to reducing impacts to this level in 2002, and successfully lowered impacts to well below this threshold in 2003. Angler compliance with the regulation has been very good (ODFW 2003).

Because of the overall reductions in impacts, the impacts of Lower Columbia commercial fisheries have become relatively greater. In 2002, new gear restrictions were initiated for these fisheries to reduce impacts on ESA-listed ESUs; also increasing catch of Upper Willamette River hatchery Chinook. To minimize capture and handling of wild winter steelhead, a gillnet mesh size of at least 8 to 9 $\frac{3}{4}$ inches is required in February when Upper Willamette River Chinook are abundant in the Lower Columbia. Steelhead excluder panels (i.e., greater than 12-inch mesh for top 5 feet) are also recommended. In March, tanglenets with a maximum mesh of 4 $\frac{1}{4}$ inches are used to reduce mortality of fish of ESA-listed populations. Release mortality for the tanglenets (25%) is about half that of the gillnets

(50%). Fishing time is reduced in mid-March or when wild steelhead are in greatest abundance. Finally, recovery boxes to resuscitate wild fish, short soak times, and reduced net lengths are mandatory (ODFW 2003; NMFS 2006). In 2001, impacts of these fisheries on wild Upper Willamette River Chinook was estimated at 4.17%, but in 2002 and 2003 these estimated impacts were 2.35% and 1.09%, respectively (Table 6-4).

Short synopses of freshwater fisheries that can impact Upper Willamette River Chinook follow. All text is condensed from ODFW (2001a), except that the commercial spring Chinook fishery-Select Areas synopsis is from ODFW (2003). Lamprey, commercial smelt, sport sturgeon, sport coho, sport warmwater gamefish, sport resident trout and sport shad fisheries have negligible impacts on spring Chinook, thus these are not included.

Sport spring Chinook fishery - lower Columbia River: The spring Chinook sport fishery from the Columbia River mouth to the I-5 Bridge is open under permanent regulations from January 1 through March 31. During most recent years, the fishery has closed effective March 11 to protect upriver spring Chinook, which typically begin to show after that date. The fishery has also been extended into April when impacts on upriver spring Chinook allow. The states of Washington and Oregon individually set regulations concerning sport fisheries in the mainstem Columbia River. However, the regulations are normally identical.

Sport spring Chinook fishery - Columbia River Select Areas: Small sport fisheries for spring Chinook occur in "Select Areas" of the lower Columbia River including Youngs Bay, Blind Slough, and Tongue Point. Select Areas are off-channel bays and sloughs where terminal fisheries are conducted for hatchery salmon which were reared and released from net pens, primarily to provide commercial fishing opportunities. Select areas are open to sport fishing under permanent regulations for the entire year to maximize opportunity on returns from net-pen release programs. Impacts to non-local Chinook are expected to be minimal. The fishery is small (< 1,000 angler trips per year in the spring).

Sport spring Chinook fishery – Willamette Basin: Fisheries for spring Chinook can occur in Multnomah Channel and the lower Willamette River upstream to Willamette Falls, lower Clackamas River from the mouth to River Mill Dam, upper Willamette River from the Falls to the mouth of the McKenzie River, Molalla River, Santiam River and Forks, McKenzie River, and the Middle Fork Willamette of the Willamette River. Chinook fisheries are open year-round or reopen under permanent regulations on January 1 in most areas and commence as fish begin entering the area beginning with Multnomah Channel and the lower Willamette River in February and March. Fisheries in tributaries near spawning areas typically close in August to protect spawners.

Sport steelhead fisheries: Fisheries for winter steelhead occur in the Willamette Basin from November through May. Fisheries are restricted to adipose fin-clipped hatchery steelhead and occur primarily in the lower Willamette River, lower Clackamas River, and Eagle Creek. Fisheries targeting winter steelhead are concentrated from December through February when spring Chinook are not present. Steelhead fisheries are typically closed with spring Chinook fisheries to avoid incidental spring Chinook catch. Fisheries for summer steelhead occur in the lower Willamette mainstem, upper Willamette mainstem,

lower Clackamas, Santiam, Middle Fork Willamette, and McKenzie rivers. Summer steelhead enter fisheries from March through October and most of the catch occurs from May through August. Spring Chinook adults may be encountered by summer steelhead anglers as both are present at the same time. The Columbia River from the mouth to the I-5 Bridge does not open to angling for hatchery steelhead until May 16 which is after the vast majority of Willamette spring Chinook have passed upstream.

Commercial spring Chinook fisheries: Winter commercial salmon fisheries occur from the Columbia River mouth upstream to Kelley Point near the mouth of the Willamette River. These fisheries currently target a small allocation of Willamette spring Chinook and are severely constrained by limitations on impacts to listed upriver spring Chinook stocks.

Commercial spring Chinook fishery - Select Areas: Fisheries for net pen-reared spring Chinook occurred in 2003 in Youngs Bay, Tongue Point/South Channel, and Blind Slough/Knappa Slough. The Tongue Point/South Channel fishery was closed early because of a high interception rate of upriver spring Chinook. Select Area fisheries were not restricted to adipose fin-clipped fish in 2003. These off-channel net pen and fishing sites are dominated by returns of local spring Chinook. A total of 7,820 spring Chinook were caught in 2003 fisheries, including an incidental catch of 1,011 Willamette spring Chinook. The estimated impact on Willamette wild spring Chinook was 114 fish or 0.76% of the return. The proportion of non-localized fish landed in 2003 was higher than average. Releases of net pen-reared spring Chinook are now of adipose fin-clipped fish.

Commercial sturgeon fisheries: Winter commercial sturgeon fisheries occur in January and February. The fishery occurs between the Columbia River mouth and Beacon Rock but most effort occurs upstream from the Willamette River. Gill net mesh size is restricted to 9-inch minimum and 9 3/4-inch maximum to avoid non-legal sturgeon and other species including spring Chinook. Fishing periods during January and February provide commercial access to a harvestable sturgeon population with minimal impact on salmonid runs. Any impacts of this fishery on Willamette spring Chinook are considered with those of the commercial salmon fishery.

Table 6-2. Significant fisheries occurring within the Willamette spring Chinook Management Area.
(Reprinted from ODFW 2001a.)

Fishery	Area	Typical open dates	Peak period	Effect ¹
Sport				
Spring Chinook	Lower Columbia R.	Jan 1 – Mar 31 ³	Mar	A
	Columbia R. select areas	Year-round	Feb – Apr	A ²
	Lower Willamette R.	Year-round ³	Mar – May	A
	Upper Willamette R.	Apr 1 – Oct 31 ³	Apr – Jun	A
	Lower Clackamas R.	Year-round ³	May – Jul	A
	Santiam R.	Jan 1 – Aug 15 ³	Jun – Jul	A
	McKenzie R.	Closed until 2001	Jun – Jul	A
	Middle Fork Willamette	Year-round	Jun – Jul	A ²
Winter steelhead	Lower Columbia R.	Jan 1 – Mar 31 ³	Nov – Mar	B
	Lower Willamette R.	Year-round ³	Nov – Mar	B
	Clackamas R.	Year-round ³	Nov – Mar	B
	Santiam R.	Year-round ³	Jan – Feb	D
Summer steelhead	Lower Columbia R.	May 16 – Dec 31	May – Aug	B
	Lower Willamette R.	Year-round ³	Mar – Jun	B
	Upper Willamette R.	Apr 1 – Oct 31 ³	Jun – Aug	B
	Clackamas R.	Year-round ³	May – Sep	B
	Santiam R.	Year-round	Apr – Aug	B
	McKenzie R.	Year-round	May – Oct	B
Shad	Lower Columbia R.	Year-round	May – Jul	B
	Lower Willamette R.	Year-round	May – Jul	B
Sturgeon	Lower Columbia R.	Year-round ³	Year-round	D
	Lower Willamette R.	Year-round	Mar – Jun	D
	Upper Willamette R.	Year-round	Jun – Sep	D
Resident trout	Lower Columbia R.	Jan 1 – Mar 31, May 27-Dec 31	None	C
	Lower Willamette R.	May 27 – Oct 31	None	C
	Upper Willamette R.	Year-round or Apr 22 – Oct 31	None	C
	Upper Clackamas R.	May 27 – Oct 31	May – Aug	C
	Santiam R.	May 27 – Oct 31	May – Aug	C
	McKenzie R.	Year-round or Apr 22 – Oct 31	May – Aug	C
	Middle Fork Willamette.	April 22 – Oct 31	May – Aug	C ²
	Standing waters	Year-round	Year-round	D ²
Warmwater species	Lower Columbia River	Year-round	Jun – Aug	D
	Willamette mainstem	Year-round	Jun – Aug	D
	Standing waters	Year-round	May – Sep	D ²
Coho salmon	Lower Willamette R.	Sep 1 – Oct 31	Sep – Oct	D
	Clackamas R.	Sep 1 – Oct 31	Sep – Oct	D
	Eagle Creek	Sep 1 – Nov 30	Sep – Nov	D
Commercial / Other				
Spring Chinook	Lower Columbia River	Determined annually	Feb – Mar	A
	Columbia R. select areas	Determined annually	Feb – Jun	A
Sturgeon	Lower Columbia River	Determined annually	Year-round	B
Smelt	Lower Columbia River	Determined annually	Dec – Mar	D
Lamprey	Willamette Falls	Jun 1 – Aug 31	July	D

¹ A = spring Chinook target fishery, B = potential for incidental encounter of spring Chinook adults, C = limited potential for incidental encounter of spring Chinook juveniles, D = spring Chinook not encountered.

Table 6-3. Willamette River spring Chinook returns and lower Willamette recreational harvest, 1946-2003.

						Lower Willamette Sport Fishery						
	Run Entering Columbia	Run Entering Willamette ¹	Falls Count	Mortalities Below Falls ²	Run Entering Clackamas R.	L. Willamette Sport Catch ³	Days Fished ⁴	Catch Per Trip	Harvest Rate	Wild Fish Impact	Trips Per Fish	
Year												
1946		68,600	53,000		3,000	12,600	61,900	0.20	18%		4.9	
1947		59,000	45,000		2,000	12,000	91,900	0.13	20%		7.7	
1948		40,100	30,000		1,800	8,300	83,600	0.10	21%		10.1	
1949		37,900	27,000		1,800	9,100	85,500	0.11	24%		9.4	
1950		24,800	14,500		1,500	8,800	73,400	0.12	35%		8.3	
1951		49,600	34,300		2,000	13,300	92,600	0.14	27%		7.0	
1952		67,500	52,200		2,800	12,500	91,100	0.14	19%		7.3	
1953		96,800	76,400		4,000	16,400	102,800	0.16	17%		6.3	
1954		44,400	31,100		1,800	11,500	104,100	0.11	26%		9.1	
1955		32,500	22,000		1,500	9,000	77,700	0.12	28%		8.6	
1956		77,600	58,600		3,000	16,000	84,100	0.19	21%		5.3	
1957		52,800	39,300		2,000	11,500	95,500	0.12	22%		8.3	
1958		62,800	45,200		2,100	15,500	137,900	0.11	25%		8.9	
1959		53,400	31,900		3,000	18,500	134,100	0.14	35%		7.2	
1960		24,200	14,400		1,800	8,000	92,300	0.09	33%		11.5	
1961		27,500	18,900		2,200	6,400	75,100	0.09	23%		11.7	
1962		38,200	26,000	100	3,000	9,100	74,000	0.12	24%		8.1	
1963		48,100	30,300	200	4,000	13,600	84,800	0.16	28%		6.2	
1964		58,400	36,300		3,500	18,600	118,700	0.16	32%		6.4	
1965		41,100	29,100		3,000	9,000	74,000	0.12	22%		8.2	
1966		44,000	28,200		3,000	12,800	85,700	0.15	29%		6.7	
1967		74,400	56,200		3,000	15,200	92,500	0.16	20%		6.1	
1968		47,500	31,500	500	2,000	13,500	91,800	0.15	28%		6.8	
1969		52,600	33,700	100	2,500	16,300	99,000	0.16	31%		6.1	
1970	65,500	53,500	34,200		1,500	17,700	118,800	0.15	33%		6.7	
1971	80,900	67,400	44,600	600	2,200	20,000	112,800	0.18	30%		5.6	
1972	58,400	47,100	26,200	200	2,200	18,500	91,200	0.20	39%		4.9	
1973	70,700	54,500	42,000	300	2,200	10,000	90,300	0.11	18%		9.0	
1974	82,400	71,800	44,500	100	2,200	25,000	154,000	0.16	35%		6.2	
1975	40,800	32,800	19,100	100	1,100	12,500	143,800	0.09	38%		11.5	
1976	45,100	40,800	22,100	100	2,200	16,400	149,100	0.11	40%		9.1	
1977	64,400	58,100	40,000	100	4,000	14,000	126,400	0.11	24%		9.0	
1978	83,330	71,400	47,500	100	4,000	19,800	157,600	0.13	28%		8.0	
1979	49,200	44,600	26,600	100	5,000	12,800	132,700	0.10	29%		10.4	
1980	43,300	42,400	27,000		8,500	7,000	83,600	0.08	17%		11.9	
1981	56,300	48,600	30,100		8,000	10,500	124,300	0.08	22%		11.8	
1982	78,000	72,500	46,200	100	7,300	18,900	142,900	0.13	26%		7.6	
1983	62,200	55,100	30,600	300	10,400	13,800	136,100	0.10	25%		9.9	
1984	84,200	74,500	43,500	400	11,300	19,400	136,900	0.14	26%		7.1	
1985	68,100	57,100	34,500	400	6,600	15,500	185,600	0.08	27%		12.0	
1986	73,600	62,500	39,200	400	7,900	15,000	171,900	0.09	24%		11.5	
1987	93,600	82,900	54,800	500	8,700	18,800	173,500	0.11	23%		9.2	
1988	118,100	104,000	70,500	200	8,700	24,600	209,700	0.12	24%		8.5	
1989	114,900	102,000	69,200	200	8,400	24,200	186,200	0.13	24%		7.7	
1990	130,600	106,300	71,300	600	11,500	23,000	200,400	0.11	22%		8.7	
1991	109,900	95,300	52,500	400	11,900	30,500	235,800	0.13	32%		7.7	
1992	75,000	68,000	42,000	1,000	11,500	13,500	188,500	0.07	20%		14.0	
1993	65,900	63,900	32,000	400	10,800	20,700	174,100	0.12	32%		8.4	
1994	49,600	47,200	26,100	1,400	7,500	11,500	155,700	0.07	24%		13.5	
1995	42,600	42,500	20,600	600	6,600	14,700	145,300	0.10	35%		9.9	
1996	34,800	34,600	21,600	1,100	5,900	6,100	63,800	0.10	18%		10.5	
1997	35,300	35,000	26,900	400	5,800	1,900	15,000	0.13	5%		7.9	
1998	45,100	45,000	34,500	300	7,400	2,800	34,500	0.08	6%		12.3	
1999	54,200	53,900	40,400	600	7,400	5,500	45,400	0.12	10%		8.3	
2000	57,500	56,100	39,100	300	7,700	11,400 ⁵	76,100	0.15	16%	14.0%	6.7	
2001	80,400	73,000	54,000	600	10,800	12,400 ⁶	101,500	0.12	10%	2.1%	8.2	
2002	121,700	109,000	83,100	600	14,400	13,600 ⁷	89,400	0.15	10%	3.0%	6.6	
2003	126,600	117,600	87,700	700	15,400	16,200 ⁸	91,400	0.14	10%	2.4%	5.6	

¹ Tribal fishermen harvested 759, 29, and 12 Chinook at Willamette Falls in 1994, 1995, and 1996 respectively.

² Number of mortalities below Willamette Falls includes predation by sea lions. For 1997, 1998, 1999, 2000, 2001, 2002, and 2003, the estimated sea lion take was 141, 150, 348, 138, 70, 143, and 143 respectively.

³ Catch totals include estimates for the mainstem Willamette bank fishery in 1947, and 1951-2001. Clackamas catch is included from 1950-70 and Eagle Creek catch is included from 1962-70. Clackamas River catch averaged 100 to 200 fish for these years.

⁴ No estimate for number of days fished was made for the L. Willamette bank fishery of 1946-74.

⁵ Total catch of 11,382 includes 8,712 kept, and 2,670 released. Hook and release mortality estimate is 299.

⁶ Total catch of 12,362 includes 6,969 kept, and 5,393 released. Hook and release mortality estimate is 706.

⁷ Total catch of 13,635 includes 10,457 kept, and 3,178 released. Wild fish hook and release mortality estimate is 369.

⁸ Total catch of 16,200 includes 13,146 kept, and 3,054 released. Wild fish hook and release mortality estimate is 373.

Table 6-4. Freshwater fishery percent impact on wild Willamette River spring Chinook, 1981-2006.

Fishery	1981- 1997	1998	1999	2000	20012 /	2002	2003	2004	2005	2006
Fishery										
L. Col.Comm. 1/	6.8	0.0	0.0	0.6	4.2	2.4	1.1	3.2	1.2	6.6
L. Col. Recr.	2.5	0.1	0.0	0.4	0.7	1.1	1.2	1.0	0.7	0.7
L. Will. Recr.	21.7	6.3	10.2	14.0	2.1	3.0	2.4	2.7	3.2	4.2
Clackamas Recr.	22.9	26.5	22.8	13.6	1.5	4.9	0.8	0.3	0.5	0.3
U. Will. Recr. 2/	1.2	0.6	0.9	1.2	(0.3)	0.5	0.3	0.1	0.3	0.4
N. San. Recr. 2/	16.5	22.7	21.7	2.0	(2.5)	0.4	0.1	0.1	0.1	0.1
McK. Recr. 2/	5.1	0.0	0.0	0.0	(1.0)	1.4	0.9	1.2	0.6	1.0
Totals by Population										
Clackamas	54.0	22.8	33.0	28.2	8.5	11.3	5.4	7.2	5.7	11.8
North Santiam	48.8	29.6	32.8	18.0	9.78	7.2	5.0	7.1	5.6	12.0
McKenzie	37.3	7.0	11.1	16.1	8.3	8.3	5.8	8.2	6.1	12.9

1/ Includes mainstem salmon/sturgeon fisheries.

2/ Rates for Upper Willamette, N. Santiam, and McKenzie for 2001 are assumed from Table 4 of the FMEP, ODFW 2001 page 28.

Threat: Hatchery Management –Impact of hatchery practices on naturally produced fish. Hatchery practices include: removal of adults for broodstock, breeding practices, rearing practices, release practices, number of fish released, water quality, blockage of access to habitat, etc.

Hatchery programs may affect salmonid population viability by affecting abundance, productivity, spatial structure and/or diversity. Summer steelhead (exotic to the ESU) and Chinook hatchery programs are conducted within three of four Upper Willamette River steelhead populations and five of seven Upper Willamette River Chinook populations. Information on hatcheries in the Willamette basin that may impact Upper Willamette River Chinook and steelhead can be found the following Hatchery Operations plans;

Clackamas Hatchery - <http://www.dfw.state.or.us/fish/HOP/Clackamas%20HOP.pdf>

Marion Forks Hatchery -

<http://www.dfw.state.or.us/fish/HOP/Marion%20Forks%20HOP.pdf>

Roaring Hatchery - <http://www.dfw.state.or.us/fish/HOP/Roaring%20River%20HOP.pdf>

South Santiam Hatchery -

<http://www.dfw.state.or.us/fish/HOP/South%20Santiam%20HOP.pdf>

McKenzie Hatchery - <http://www.dfw.state.or.us/fish/HOP/McKenzie%20HOP.pdf>

Leaburg Hatchery - <http://www.dfw.state.or.us/fish/HOP/Leaburg%20HOP.pdf>

Willamette Hatchery - <http://www.dfw.state.or.us/fish/HOP/Willamette%20HOP.pdf>

Threat: Hydropower/Flood Control Management – Impact of hydropower/flood control systems on naturally produced fish.

Operation of Upper Willamette flood control/hydropower dams may affect salmonid population viability by affecting abundance, productivity, spatial structure and/or diversity. Flood control/hydropower dams are located in four of six Chinook population areas above Willamette Falls and in two of four steelhead population areas above Willamette Falls. Development and operation of tributary flood control/hydropower dams dramatically alters habitat conditions in tributaries within the Upper Willamette basin where these structures exist.

Threat: Land Management – Impact of current land use activities on naturally produced fish. Land use practices include timber harvest, agriculture, urbanization, transportation, mining, etc. This category includes both current land use practices that are causing limiting factors and impairing fish populations as well as current practices that are not adequate to restore limiting factors caused by past practices.

Land management practices may affect salmonid population viability by affecting abundance, productivity, spatial structure and/or diversity. Conditions in the tributaries that support populations of Upper Willamette River steelhead and Chinook have changed considerably over the last 150 years.

Threat: Introduced species – Impacts of non-native plants or animals on naturally produced fish. The presence of introduced species, both predators and competitors, may affect salmonid population viability by affecting abundance, productivity, spatial structure and/or diversity. The impact of non-native hatchery fish is considered under the hatchery practices.

6.1.5 Prioritizing Limiting Factors and Threats

Oregon believes that a common pitfall in the design and successful implementation of recovery plans is the failure to provide strategic guidance. Inadequate strategic guidance dilutes the effectiveness of design implementation of any recovery plan, because recovery actions can be dispersed across issues that have relatively little positive affect on improving viability of the listed species. Rather than provide a laundry list of all the potential LF/Ts that may impact recovery, this plan provides strategic guidance by identifying those LF/Ts that are essential to recovery. Two categories of essential LF/Ts are identified for this plan. Key limiting factors and the causative threat category are issues that currently have the largest adverse impact on population viability. Secondary limiting factors note issues that may also currently have significant adverse impacts on population viability, but to a lesser extent than the key limiting factors and causative threat categories.

6.1.6 Future or Cumulative Limiting Factors and Threats

“Anadromous salmonids have managed to persist in the face of numerous climatic events and changes. The long term persistence of Chinook salmon populations depends on their ability to withstand fluctuations in environmental conditions. It is apparent that the combination of tremendous freshwater habitat loss, and extremely small anadromous salmonid populations has caused these fish to be more vulnerable to extirpation arising from natural events. Until salmonid populations reached their recent critical levels, these environmental conditions largely went unnoticed. Therefore, it would seem that environmental events and their impacts on remaining salmonid populations may become a more significant factor for decline as unstable Chinook salmon populations reach particularly low levels.” (NMFS, 1998)

Climate change, in concert with predicted increases in the human population and the likely resultant changes to habitat, is expected to have detrimental effects on recovery of ESA listed salmonids. The Independent Scientific Advisory Board recently completed a review of climate change impacts on Columbia River Basin fish and wildlife (ISAB 2007) and of human population growth on Columbia River Basin fish and wildlife (ISAB 2007b). The potential ecological and management issues related to both climate change and human population growth are complex and not precisely predictable. Likely impacts of climate change include increased winter flooding, decreased summer and fall streamflows, and elevated warm season temperatures in streams and estuaries. All of these conditions are likely to further degrade conditions for salmonids in relation to contemporary habitat conditions that are degraded (in terms of salmon survival) from historical conditions. Table 6-5 summarizes the observed and projected impacts of climate change relevant to salmonids in the Pacific Northwest.

Although the impacts of global climate change are less clear in the ocean environment, early modeling efforts suggest that, warmer temperatures are likely to increase ocean stratification, which in the past has coincided with relatively poor ocean habitat for most Pacific Northwest salmon, herring, anchovies, and smelt populations (CIG, 2004).

Regarding the key findings of the ISAB report on climate change (May 11, 2007), here are some examples of what to expect in the Columbia River basin.

- Adverse impacts on salmon from changes in snow pack, streamflows, and water quality
- More incidences of wildfire, more incidence or impacts of predation, occurrence of ecological changes detrimental to salmon, etc.
- It will be difficult to predict effects of climate change at the spatial scales where management actions are implemented
- There will be a loss of 20 – 40% of salmon habitat by 2090
- The operation of the Hydro-system will magnify adverse effects of climate change
- Climate change will adversely impact fish will be less favorable to salmon
- Climate change has been poorly addressed in planning, improving planning is difficult
-

Regarding the key recommendations of the ISAB report on climate change (May 11, 2007), here are some *examples* of potential actions that could be taken to reduce or mitigate for the effects of future climate change.

- Provide better technical assistance to planners
- Establish habitat reserves

- Take a variety of management action to minimize water temperature increases and augment flow
- Construct cool-water storage-reservoirs
- Make structural alterations at dam forebays and fish ladders
- Transport juvenile and adult salmon through the Columbia River
- Encourage greater harvest of introduced fish species
- Implement changes hydro-system flow regimes that would benefit salmon
- Reduce number of hatchery fish released
- Reduce allowable harvest in fisheries

Table 6-5. Observed and Projected Impacts of Climate Change in Major Climate/Hydrologic Indicators (Sources: Mote et al. 1999; Miles et al. 2000; Mote 2003; Snover et al. 2003; Steward et al. 2004; Wiley 2004 as cited in CIG, 2004).

Indicator	Observed 20th century changes	Projected mid 21st century changes
Temperature	Region-wide warming of about 1.5°F (1920-2000). 1990-2000 was the warmest decade on record, and was warmer than any other decade by 0.9°F.	• 2020s: predicted average increase of 2.7°F. • 2040s: predicted average increase of 4.1°F.
Precipitation	Region-wide increase in precipitation since 1920.	Uncertain, although most models project wetter winters and drier summers.
April 1 snowpack	Substantial declines (>30%) at most monitoring stations below 6,000 feet. Data collected during the 20th century revealed widespread increases in average annual temperature and precipitation, and decreases in the April 1 snow water equivalent.	Projected decrease in April 1 snowpack for the Cascades Mountains in Washington and Oregon relative to 20th century climate: • 44% by the decade of the 2020s based on +3°F avg. temp change. • 58% by the decade of the 2040s based on +4.5°F avg temp change.
Timing of peak spring runoff	Advanced 10-30 days earlier during the last 50 years, with greatest trends in the PNW.	Earlier peak spring runoff expected on the order of 4-6 weeks.
Summer streamflow	Declining in sensitive PNW basins. Example: May-Sept inflows into Chester Morse Lake in the Cedar River watershed (WA) as a fraction of annual flows have decreased 34% since 1946.	Continued and more wide-spread declines. Example: April-Sept natural streamflow in the Cedar River (WA) projected to decrease 35% by the 2040s (based on a 2.5°F increase in average temperature.

The ISAB also recently completed a review of the impact of human population growth on Columbia River Basin fish and wildlife (ISAB 2007b). In this report they conclude that:

- Population growth will increase demand for resources key to fish and wildlife populations: water, land, and forests.
- Increased demand for residential land is accelerating the rate of conversion of forest and agricultural lands.

- Changes in land use will affect water use and management and, ultimately, fish and wildlife habitat.
- The effects of climate change and population growth will combine to increase pressure on fish and wildlife habitats.
- The dominant ongoing pattern of settlement in the Columbia River Basin is exurban sprawl which causes loss, degradation, and fragmentation of habitat. It also increases infrastructure costs, social conflict, and harmful interactions among people and wildlife.
- Demands for fresh water from surface and groundwater will increase. Decreases in the snow pack at higher elevations, resulting from climate change, will exacerbate this situation especially during low-flow summer and fall seasons.
- Urbanization will increase the amount of impervious surfaces in watersheds (pavement, roofs etc.). As a result, precipitation cannot penetrate into the soil, causing an increase in surface runoff during storm events and a reduction base flows due to reduced groundwater recharge.
- Population-related factors external to the Columbia River Basin will affect fish and wildlife habitat. These include international trade, shipping, dredging, hazardous material transport, and airborne pollution.

Many of the recommendation in the ISAB reviews of future climate change and human population growth are consistent with management actions in the current draft Recovery Plan for Upper Willamette River Chinook and steelhead. Oregon has also modeled the additional productivity and population abundance improvements that could be required to mitigate potential detrimental effects of climate change, human population increases and other unknown factors on recovery of Upper Willamette River Chinook and steelhead.

Oregon will consider the recommendations of these two ISAB reports during the process of developing the next draft of the Upper Willamette recovery plan.

6.2 Oregon's Findings

Section 6.2 describes Oregon's findings regarding limiting factors and threats for each species and population at all life cycle stages.

6.2.1 Key Threat Themes across Populations

Limiting factors in three threat categories are so common across species, populations, and/or geographic areas that they constitute themes that are broadly relevant to recovery management action in the Upper Willamette River steelhead and Chinook ESUs. These threat themes are:

1. Hatchery management
2. Hydropower/flood control management
3. Historical and contemporary land use management

Hatchery Management

Interactions with hatchery fish exert key adverse effects on all six Chinook populations above Willamette Falls and two of four steelhead populations. The key threats to Chinook occur at the adult spawner stage in the tributaries – specifically –hatchery fish interbreeding with wild fish and a risk of genetic introgression. Key threats to steelhead occur at several juvenile life stages (competitive interactions) as well as at the adult spawner stage.

Hydropower/Flood Control Management

Hydropower/flood control management exerts key adverse effects at multiple life stages for every steelhead and Chinook population in basins where these populations and structures coexist (North and South Santiam, McKenzie, Middle Fork Willamette). The key threats to Chinook occur within the tributaries, in the mainstem Willamette above Willamette Falls, and in the Estuary. Key threats to steelhead occur in the tributaries and in the estuary. Adverse conditions include altered water temperatures and flows; altered food webs; impaired sediment routing; and altered habitat complexity and off-channel habitat availability.

Limiting Factors

- *Loss of population traits and productivity.* Low adult abundance is attributable to direct mortality of smolts at a dam, or to direct mortality or delayed passage of returning adults at a dam. Selective mortality resulting in altered genetic and phenotypic characteristics.
- *Habitat access.* Impaired or blocked access to spawning and rearing areas upstream from a dam, or restriction of spawning and rearing to sub-optimal habitat downstream of a dam. Juveniles are also affected because they can not migrate downstream through the dam or survive downstream passage through or over the dams.
- *Hydrograph/water quantity.* Changes in flow patterns affect Upper Willamette River steelhead and Chinook migration and survival. Juvenile and adult migration behavior and

travel rates are influenced by river flow. Regulation of flow from Upper Willamette dams can stimulate or delay juvenile migration or adult migration, thereby affecting the timing of juvenile arrival in the estuary and ocean, or adult arrival at headwater holding and spawning areas. Rapid flow fluctuations can cause adverse redistribution of spawners, leave redds dewatered, and strand juveniles.

Changes in hydrology impair fine sediment routing and gravel recruitment. For example, historically spring freshets moved sand down the Columbia River and into the estuary, where it formed shallow-water habitats that are vital for salmonids, particularly ocean types (Lower Columbia River Estuary Partnership 2006). Today, alterations to spring freshets have reduced sand discharge in the Columbia River estuary to 70% of nineteenth-century levels (Jay and Kukulka 2002). It is likely that the magnitude of change in sand transport affects habitat-forming processes.

- *Physical habitat quality.* Modification of riverine habitat into impoundments resulted in changes in habitat availability, migration patterns, and feeding ecology. For example, 1) downstream migration is significantly slower through impoundments; 2) food webs are different in the impoundments than in natural rivers; 3) juvenile steelhead and Chinook may not migrate downstream through dams or may not survive downstream passage through or over dams.
- *Food web.* Loss of wetland and side channel habitat has reduced the local macrodetritus inputs from terrestrial and riparian habitats that supported the historical food web. Detrital sources from emergent wetlands in the estuary are approximately 84% less than they were historically (Bottom et al. 2005). The current food web in the estuary is based on decaying phytoplankton delivered from upstream reservoirs instead of from macrodetrital inputs of plant materials that once originated from emergent, forested, and other wetland rearing areas in the estuary (Lower Columbia River Estuary Partnership 2004a). The switch in primary production in the estuary from a macrodetritus-based source to a microdetritus-based source has lowered the productivity of the estuary (Bottom et al. 2005).

The substitution of detrital sources in the estuary also has contributed to changes in the spatial distribution of the food web (Bottom et al. 2005). Historically the macrodetritus based food web was distributed evenly throughout the estuary, including the many shallow-water habitats favored by ocean-type salmonids. The contemporary microdetrital food web is concentrated within the estuarine turbidity maximum in the middle region of the estuary (Bottom et al. 2005). This location is less accessible to ocean-type fish such as chum salmon that use peripheral habitats, and more accessible to species such as American shad that feed in deep-water areas. Pelagic fish such as shad may also benefit from the fact that the estuarine turbidity maximum traps particles and delays their transport to the ocean up to four weeks, compared to normal transport of around two days (Lower Columbia River Estuary Partnership 2004a). The estuarine turbidity maximum is thought to contain bacteria that attach to detritus. Together these represent the primary food source in the estuary today (Lower Columbia River Estuary Partnership 2004a).

- *Water quality.* Flow regulation and reservoir construction have changed average water temperatures from the ranges that the species historically experienced in the Upper

Willamette River. Altered water temperatures can adversely affect migration of adult steelhead and Chinook destined to headwater holding and spawning areas. Cool temperatures can delay migration and warm summer temperatures can increase susceptibility to disease. Flow regulation and reservoir construction also have increased water clarity, potentially increasing vulnerability to predation, decreasing food availability, and increasing susceptibility to disease.

Flow regulation and reservoir construction on the Columbia River have caused average water temperatures to increase in the estuary. Water quality measurements at Bonneville Dam indicate that periods of increased temperatures are lasting longer than they did historically (National Research Council 2004). Currently, average and maximum values of Columbia River water temperatures are well above 20° C, which approaches the upper limits of thermal tolerance for cold-water fishes such as salmon (National Research Council 2004).

- *Predation.* Ecosystem alterations attributable to dams have increased rates of predation on naturally produced salmon and steelhead juveniles. Changes in flows and sediment transport in lower Columbia River has likely increased predation in the estuary and plume environments. Marine mammals (pinnepeds) prey on adult salmon.

Historical and Current Land Management

Past and current land management exerts key adverse effects at the winter parr life stage within tributaries for every population of steelhead in the ESU. It also wields key adverse effects in both tributary and estuary habitats for all Chinook populations. Adverse conditions include isolation of rivers from floodplains, loss of habitat complexity, and reduced access to off-channel rearing habitats.

Limiting Factors

- *Physical habitat quality.* Past and present land management affects the quality and complexity of salmonid habitats.

Historical complex habitats in the Columbia River estuary have been modified through channelization, diking, development and other practices over the past 200 years, causing the surface area of the estuary to decrease by approximately 20% (Fresh et al. 2005). Dredging and the disposal of sand and gravel have been a major cause of estuarine habitat loss over the last century (Lower Columbia River Estuary Partnership 2004a). Currently, three times more sand is dredged from the estuary than is replenished by upstream sources (Lower Columbia River Estuary Partnership 2004a). Additional losses of vegetated wetlands in the Columbia River estuary are attributable to filling activities, with deposition of dredged materials accounting for most of the filling activities in the estuary (Fresh et al. 2005).

- *Habitat access.* There has been extensive loss of access to peripheral wetland, off-channel habitat and side channel habitat throughout the Willamette River system as well as the Columbia River mainstem and estuary.
- *Hydrograph/water quantity.* Changes in the hydrograph alter the natural pattern of flows

over the seasons, causing inadequate flow, scouring flow, or other flow conditions that inhibit the development and survival of salmonids. Flows needed for migration, spawning or rearing area also reduced because of water withdrawals for municipal, irrigation or other uses. Low flows may decrease survival by limiting delivery of nutrients and dissolved oxygen to incubating eggs.

- *Water quality.* Land use practices and water withdrawals contribute to elevated water temperatures. High water temperatures can be lethal to salmonids, contribute to disease, or act as temporary adult migration barriers.

Toxic contaminants found throughout the lower mainstem Columbia and estuary have detrimental effects on salmonids. The U.S. Geological Survey's National Stream Quality Accounting Network (NASQAN) program reports that a wide range of commonly used pesticides have been detected at sampling sites near Bonneville Dam and at the confluence of the Willamette and Columbia rivers (Lower Columbia River Estuary Partnership 2006; Fresh et al. 2005). Water-soluble contaminants, trace metals, and chlorinated compounds have been detected in the estuary (Fresh et al. 2005), and DDT, PCBs, dioxins, and metals have been detected at elevated levels in tissue from fish in the estuary (Lower Columbia River Estuary Partnership 2004a). In a 2005 study by Loge et al., cumulative delayed disease-induced mortalities were estimated at 3% and 18% for juvenile Chinook residing in the Columbia River estuary for 30 to 120 days, respectively (Loge et al. 2005). The U.S. Environmental Protection Agency recently identified PCB and DDT hot spots within the estuary, including near Longview, West Sand Island, the Astoria Bridge, and Vancouver (Fresh et al. 2005).

- *Predation.* As a result of estuary habitat modifications, the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species has increased (Lower Columbia River Estuary Partnership 2006; Fresh et al. 2005). In 1997 it was estimated that avian predators consumed 10 to 30 percent of the total estuarine salmonid smolt production in that year (Lower Columbia River Estuary Partnership 2004b). The draft 2005 season summary of Research, Monitoring, and Evaluation of Avian Predation on Salmonid Smolts in the Lower and Mid-Columbia River (Collis and Roby 2006) estimates that 3.6 million juvenile salmonids were consumed by terns in 2005. Stream-type juvenile salmonids are most vulnerable to avian predation by Caspian terns because they use deep-water habitat channels that have relatively low turbidity and are close to island tern habitats. Double-crested cormorants consume a similar number of juvenile salmonids (approximately 3.6 million juveniles) from their East Sand Island nesting grounds (Collis and Roby 2006).

6.2.2 Key Limiting Factors and Threats to Recovery of Upper Willamette River Chinook Populations

This section summarizes the primary limiting factors and threats to the recovery of six of the seven independent Chinook populations in the Upper Willamette River ESU — Molalla, North Santiam, South Santiam, Calapooia, McKenzie and Middle Fork Willamette. Clackamas Chinook are included in this ESU but are addressed in Oregon's Recovery Plan for the Lower Columbia River. Descriptions of population-specific limiting factors and threats follow in sections 6.2.4 through 6.2.9. Table 6-6 identifies the key and secondary threats to recovery of the six Upper Willamette River Chinook populations. Table 6-7 shows the effects of the limiting factors on the different populations and life stages, locations where impacts occur, specific threats, and VSP parameters affected. See section 6.2.1 for a discussion of limiting factors and threats (such as Columbia River harvest impacts and effects from the Columbia River hydro system) that are common to Upper Willamette River Chinook populations.

Key threats to the recovery of Upper Willamette River Chinook occur throughout their life cycle and in all spatial areas except the ocean and in West-side tributaries to the Willamette.

Harvest Management

Harvest is not considered a key threat to any of the populations.

Hatchery Management

Hatchery threats exert key adverse effects on all Upper Willamette River Chinook at the adult spawning life stage. Impacts related to this threat category involve the risk of altered genetic traits resulting from interbreeding with hatchery Chinook.

Hydropower/Flood Control Management

Hydropower/flood control-related threats exert key adverse effects on multiple life stages of Chinook within North Santiam, South Santiam, McKenzie, and Middle Fork Willamette populations where these structures are present. They also affect the fingerling/subyearling and yearling life stage of all six Upper Willamette River Chinook populations in the mainstem Willamette and estuary. Impacts from this threat category include:

1. elevated flows during spawning and dewatering redds below dams;
2. reduced peak flows that cause a reduction of channel complexity and diversity of rearing habitat;
3. elevated water temperatures below the North Santiam, South Santiam, and Middle Fork Willamette dams that cause premature hatching of Chinook eggs and emergence of fry;
4. mortality at North Santiam, South Santiam, and Middle Fork Willamette dams caused by downstream passage through turbines and smolts in the reservoirs being unable to locate downstream passage at the dams;
5. impaired access to habitat above dams on the North Santiam, South Santiam, McKenzie,

and Middle Fork Willamette;

6. pre-spawning mortality caused by crowding and high water temperatures below dams on the Middle Fork Willamette;
7. reduced macrodetrital inputs from near elimination of over-bank events and the separation of the river from its floodplain;
8. increased microdetrital inputs in the estuary due to reservoirs;
9. impaired fine sediment recruitment due to settling behind dams in the Columbia and Willamette; and
10. altered flows that change estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Land Management

Present and historical land use-related threats exert key adverse effects on several juvenile life history stages of all Upper Willamette River Chinook populations in tributaries and the estuary; and at two juvenile life stages in the mainstem Willamette for the McKenzie and Middle Fork Willamette populations. Impacts in the tributaries include:

1. elevated water temperatures that cause decreased survival and/or growth of juveniles in the Molalla, North Santiam, South Santiam, and Calapooia;
2. impaired physical habitat that typically result in degraded rearing potential for winter parr life stage of juveniles in the basins that support all populations and in the mainstem Willamette below the McKenzie and Middle Fork Willamette populations;
3. impaired access to habitat above Upper and Lower Bennett dams on the North Santiam, Lebanon dam on the South Santiam, and dams on the Calapooia;
4. loss of holding pools that cause increased prespawning mortality in the Molalla and Calapooia;
5. elevated water temperatures that cause prespawning mortality in the Molalla, and Calapooia; and
6. fingerling/sub-yearlings and yearlings of all populations are adversely affected in the estuary by reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.

Table 6-6. Key and Secondary Limiting Factors and Threats to Recovery of Upper Willamette River Chinook populations, except Clackamas.

Threats	Population	Tributaries								West Side Tributaries	Mainstem Willamette (above falls)		Estuary (below Bonneville and Willamette Falls)			Ocean
		Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner		Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	
Harvest	Molalla															
	North Santiam															
	South Santiam															
	Calapooia															
	McKenzie															
	MF Willamette															
Hatchery	Molalla								3				4a			
	North Santiam				4b				3				4a			
					6c											
	South Santiam				4b				3				4a			
					6c											
	Calapooia								3				4a			
	McKenzie				4b											
Hydropower/ Flood Control					6c				3				4a			
					6d											
	MF Willamette								3				4a			
	Molalla												9j			
	North Santiam	9b			10d		1d	2b	7c			10d	5a,5b,7h,10f			
		7b						2k					9j			
	South Santiam	9e			10d		1e	2c				10d	5a,5b,7h,10f			
Landuse		7d						2l					9j			
	Calapooia											10d	5a,5b,7h,10f			
	McKenzie	9g			10d			2d	7e			10d	9j			
													5a,5b,7h,10f			
	MF Willamette	9f			10d		1f	2e	7f			10d	9j			
		7g						2m					5a,5b,7h,10f			
	Molalla	7a	8a	9a	8a	8a		8b					6e,8a,9a,9h,9i			
Introduced Species				10b				9c					5a			
	North Santiam			8a	9a	8a		2f		8a	8a		6e,8a,9a,9h,9i			
					8a								5a			
	South Santiam			8a	8a	8a		2g		8a	8a		6e,8a,9a,9h,9i			
				9a									5a			
	Calapooia	7a	8a	8a	8a			8b		8a	8a		6e,8a,9a,9h,9i			
				10b				9c					5a			
Introduced Species	McKenzie			8a	8a	8a				8a	8a		6e,8a,9a,9h,9i			
				9a									5a			
	MF Willamette			8a	8a	8a				8a	8a		6e,8a,9a,9h,9i			
				9a									5a			
	Molalla															
	North Santiam															
Introduced Species	South Santiam															
	Calapooia															
	McKenzie															
	MF Willamette															

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors to recovery of Upper Willamette River Chinook populations

- 1d Mortality at North Santiam hydropower/flood control dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
- 1e Mortality at South Santiam hydropower/flood control dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
- 1f Mortality at Middle Fork Willamette hydropower/flood control dams. This mortality is due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
- 2b Impaired access to habitat above North Santiam hydropower/flood control dams.

- 2c Impaired access to habitat above South Santiam hydropower/flood control dams.
- 2d Impaired access to habitat above McKenzie hydropower/flood control dams.
- 2e Impaired access to habitat above Middle Fork Willamette hydropower/flood control dams.
- 2f Impaired access to habitat above Upper and Lower Bennett dams.
- 2g Impaired access to habitat above Lebanon dam.
- 2h Impaired access to habitat above Calapooia dams.
- 2m Prespawning mortality due to crowding and high water temperatures below Middle Fork Willamette hydropower/flood control dams.
- 3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- 5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
- 5b Increased microdetrital inputs due to reservoirs.
- 7f Lack of gravel recruitment below Middle Fork Willamette hydropower/flood control dams due to gravel capture in upstream reservoirs.
- 7h Impaired fine sediment recruitment due to dam blockage.
- 8a Impaired physical habitat from past and/or present land use practices (tributaries). Specific concerns include: removal of large wood from stream channels; inadequate large wood recruitment due to impaired riparian conditions; stream straightening and channelization; revetments; loss of access to off-channel habitat; gravel mining and floodplain connectivity to stream channels
- 8b Loss of holding pools from past and/or present land use practices resulting in increased prespawning mortality.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9b Elevated water temperatures below the North Santiam hydropower/flood control dams resulting in premature hatching and emergence.
- 9c Elevated water temperatures from past and/or present land use practices leading to prespawning mortality.
- 9e Elevated water temperatures below the South Santiam hydropower/flood control dams resulting in premature hatching and emergence.
- 9f Elevated water temperatures below Middle Fork Willamette hydropower/flood control dams resulting in premature hatching and emergence.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.
- 10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors to recovery of Upper Willamette River Chinook populations

- 2k Prespawning mortality due to crowding below North Santiam hydropower/flood control dams.
- 2l Prespawning mortality due to crowding below South Santiam hydropower/flood control dams.
- 4a Competition with hatchery fish of all species.
- 4b Competition with naturally produced progeny of hatchery spring Chinook.
- 6c Predation by hatchery summer steelhead smolts.
- 6d Predation by hatchery rainbow.
- 6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
- 7a Fine sediment in spawning gravel from past and/or present land use practices.
- 7b Streambed coarsening below North Santiam hydropower/flood control dams due to reduced peak flows.
- 7c Lack of gravel recruitment below North Santiam hydropower/flood control dams due to gravel capture in upstream reservoirs.
- 7d Streambed coarsening below South Santiam hydropower/flood control dams due to reduced peak flows.

- 7e Lack of gravel recruitment below McKenzie hydropower/flood control dams due to gravel capture in upstream reservoirs.
- 7g Streambed coarsening below Middle Fork Willamette hydropower/flood control dams due to reduced peak flows.
- 8a Impaired physical habitat from past and/or present land use practices. Specific concerns include: removal of large wood from stream channels; inadequate large wood recruitment due to impaired riparian conditions; stream straightening and channelization; revetments; loss of access to off-channel habitat; gravel mining and floodplain connectivity to stream channels
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9g Elevated water temperatures below McKenzie hydropower/flood control dams resulting in premature hatching and emergence.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.
- 10b Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

Table 6-7. Effects of Limiting Factors to Recovery of Upper Willamette River Chinook, except Clackamas.

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
Hatchery Management			
<i>Population traits -</i> Hatchery fish interbreeding with wild fish (3)	<i>Spring Chinook:</i> spawners, tributaries (1)	Hatchery fish interbreeding with wild fish results in a risk of altered genetic traits.	Abundance, productivity, diversity
<i>Competition-</i> with hatchery fish of all species (4a)	<i>Spring Chinook:</i> parr & smolts, estuary (2)	Mortality of naturally produced juvenile salmonids which must compete with numerous hatchery fish for limited habitat and food in estuary.	Abundance, productivity, diversity
<i>Competition-</i> with produced progeny of hatchery fish (4b)	<i>Spring Chinook:</i> fry, summer parr, winter parr, tributaries (2)	Competition with naturally produced progeny of hatchery spring Chinook.	Abundance, productivity, diversity
<i>Predation-</i> by hatchery smolts (6c)	<i>Spring Chinook:</i> fry, parr, winter parr; tributaries (2)	Predation by hatchery summer steelhead smolts.	Abundance, productivity
<i>Predation-</i> by hatchery rainbow (6d)	<i>Spring Chinook:</i> fry, summer parr, winter parr; tributaries (2)	Predation by hatchery rainbow trout.	Abundance, productivity, diversity
Hydropower/Flood Control Management			
<i>Habitat access-</i> Direct mortality associated with hydropower/flood control dams (1d and 1e)	<i>Spring Chinook:</i> smolts, tributaries (1)	Mortality at N. Santiam, S. Santiam & MF Willamette dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.	Abundance, productivity, diversity, spatial structure
<i>Habitat access-</i> impaired access to habitat above dams (2b–2h)	<i>Spring Chinook:</i> returning adults, tributaries (1)	Impaired access to habitat above dams: N. Santiam, S. Santiam, McKenzie, MF Willamette,	Abundance, productivity, diversity, spatial structure
<i>Population traits-</i> prespawning mortality (2m)	<i>Spring Chinook:</i> returning adults, tributaries (1)	Prespawning mortality due to crowding and high water temperatures below MF Willamette hydropower/flood control dams	Abundance, productivity
<i>Population traits-</i> prespawning mortality (2k & 2l)	<i>Spring Chinook:</i> returning adults, tributaries (2)	Prespawning mortality due to crowding below N Santiam & S Santiam hydropower/flood control dams	Abundance, productivity
<i>Food web-</i> Reduced macrodetrital inputs (5a)	<i>Spring Chinook:</i> fingerling, subyearling and yearling, estuary (1)	Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.	Abundance, productivity, diversity
<i>Food web-</i> Increased microdetrital inputs (5b)	<i>Spring Chinook:</i> fingerling, subyearling and yearling, estuary (1)	Increased microdetrital inputs due to reservoirs.	Abundance, productivity, diversity
<i>Physical habitat quality-</i> gravel recruitment (7c,	<i>Spring Chinook:</i> spawners, tributaries - MF Willamette (1), N. Santiam (2),	Lack of gravel recruitment below hydropower/flood control dams due to	Abundance, productivity

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
7e & 7f)	McKenzie (2)	gravel capture in upstream reservoirs. Is not considered a problem in S. Santiam because of gravel input from Wiley Cr.	
Physical habitat quality- Impaired fine sediment routing (7h)	Spring Chinook: fingerling, subyearling, yearling, estuary (1)	Impaired fine sediment recruitment due to dam blockage.	Abundance, productivity, diversity
Physical habitat quality- Streambed coarsening (7b, 7d & 7g)	Spring Chinook: eggs and alevins, tributaries – N. Santiam (2), S. Santiam (2), MF Willamette (2)	Streambed coarsening below N. Santiam, S. Santiam and MF Willamette hydropower/flood control dams due to reduced peak flows.	Abundance, productivity
Water quality-Elevated water temperatures (9b, 9e, 9f & 9g)	Spring Chinook: eggs and alevins, tributaries – N. Santiam (1), S. Santiam (1), MF Willamette (1), McKenzie (2)	Elevated water temperatures below hydropower/flood control dams resulting in premature hatching and emergence.	Abundance, diversity, and productivity
Water quality-Elevated water temperatures (9j)	Spring Chinook: fingerling, subyearling, yearling, estuary (2)	Elevated water temperatures due to reservoir heating.	Abundance, productivity
Hydrograph/water quantity- Altered hydrology (10d)	Spring Chinook: fry and parr, tributaries (1); parr and smolts, mainstem (2). Molalla fish are not considered to be significantly impacted by Willamette River or Westside tributary conditions because of the Molalla's location. Molalla Spring Chinook and winter steelhead have minimal use of the habitats.	Reduced peak flows decrease channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.	Abundance, productivity, diversity
Hydrograph/water quantity- Altered hydrology (10f)	Spring Chinook: fingerling, subyearling, yearling estuary (1)	Altered flows due to hydropower system result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat and sediment transport.	Abundance, diversity, and productivity
Land Management			
Physical habitat quality- Fine sediment in spawning gravel (7a)	Spring Chinook: eggs & alevin, tributaries (2)	Fine sediment in spawning gravel from past and/or present land use practices.	Abundance, productivity,
Physical habitat quality- Reduced complexity and impaired stream and watershed function (8a)	Spring Chinook: winter parr, tributaries (1)	Past and present land practices reduce instream habitat complexity and access to off-channel habitat (removal of large wood from the stream channel, altered riparian conditions, channel straightening, revertsments, gravel mining, floodplain connectivity).	Abundance, productivity, distribution, diversity
Habitat access- Reduced habitat access and connectivity (8a)	Spring Chinook: winter parr, tributaries (1)	Past and present land management practices reduce access to off-channel habitat and floodplain.	Abundance, productivity,
Physical habitat quality- loss of pools (8b)	Spring Chinook: returning adults, tributaries (1)	Loss of holding pools from past and/or present land use practices increases prespawning mortality.	Abundance, productivity,

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
<i>Physical habitat quality-</i> Impaired riparian condition (9a)	<i>Spring Chinook</i> : summer parr, tributaries (1)	Past and present land management practices have altered riparian conditions resulting in reduced stream shading and elevated water temperatures.	Abundance, distribution, diversity, and productivity
<i>Water quality –</i> temperature (9a, 9c)	<i>Spring Chinook</i> : summer parr, tributaries (1); <i>Spring Chinook</i> : returning adults, tributaries (1)	Elevated water temperatures from past and/or present land use practices resulting in decreased juvenile survival and/or growth, and prespawning mortality.	Abundance, distribution, diversity, and productivity
<i>Water quality – toxicity</i> (9h, 9i)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (2)	Toxicity due to agricultural, urban and industrial practices.	Abundance, diversity, and productivity
<i>Hydrograph/water</i> <i>quality- water</i> <i>withdrawals</i> (10b)	<i>Spring Chinook</i> : summer parr, tributaries (2)	Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.	Abundance, productivity
<i>Predation- birds</i> (6e)	<i>Spring Chinook</i> : parr and smolts, estuary (2)	Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.	Abundance, diversity, and productivity

6.2.3 Key Limiting Factors and Threats to Recovery of Upper Willamette River Steelhead Populations

This section summarizes the primary limiting factors and threats to the recovery of the four independent steelhead populations in the Upper Willamette River ESU — Molalla, North Santiam, South Santiam and Calapooia. Descriptions of population-specific limiting factors and threats follow in sections 6.2.4 to 6.2.7. Table 6-8 identifies the key and secondary threats to recovery of the four Upper Willamette River steelhead populations. Table 6-9 shows the effects of the limiting factors on the different populations and life stages, locations where impacts occur, specific threats, and VSP parameters affected. See section 6.2.1 for a discussion of limiting factors and threats (such as Columbia River harvest impacts and effects from the Columbia River hydro system) that are common to Upper Willamette River steelhead populations.

Key threats to the recovery of Upper Willamette River steelhead occur throughout their life cycle and in all spatial areas except the ocean and in West-side tributaries to the Willamette.

Harvest Management

Harvest is not considered a key threat at any steelhead life stage, at any spatial location, or for any population.

Hatchery Management

Hatchery threats exert key adverse effects at juvenile and adult life stages for the North and South Santiam populations. Impacts from hatchery management involve competition with naturally produced progeny of hatchery summer steelhead, competition with residual hatchery summer-steelhead smolts, and the risk of altered genetic traits resulting from interbreeding with hatchery summer steelhead.

Hydropower/Flood Control Management

Threats associated with the hydropower/flood control system exert key adverse effects on multiple life stages of steelhead populations within North and South Santiam basins where these structures are present; affect the smolt life stage of North Santiam, South Santiam and Calapooia populations in the mainstem Willamette; and also affect the yearling life stage of all four Upper Willamette River steelhead populations in the estuary. Impacts from this threat category include:

1. elevated flows during spawning and dewatering redds below dams;
2. reduced flows during spring (associated with the reservoir fill period) that result in increased water temperatures and increased potential for disease;
3. reduced peak flows that cause a reduction of channel complexity and diversity of rearing habitat;
4. mortality at North Santiam, South Santiam, and Middle Fork Willamette dams caused by downstream passage through turbines and smolts in the reservoirs being unable to locate downstream passage at the dams;

5. impaired access to habitat above the dams;
6. reduced macrodetrital inputs form near elimination of over-bank events and the separation of the river from its floodplain;
7. increased microdetrital inputs in the estuary due to reservoirs;
8. impaired fine sediment recruitment due to settling behind dams in the Columbia and Willamette; and
9. altered flows that change estuarine habitat and plume conditions, impaired access to off-channel estuarine habitat, and impaired sediment transport.

Land Management

Land use impacts exert key adverse effects on all Upper Willamette River steelhead populations at the winter parr life history stage in tributaries and at the smolt life stage in the estuary. Impacts in the tributaries involve impaired physical habitat that limits the availability of over-wintering shelter. Impacts in the estuary involve reduced macrodetrital inputs form near elimination of over-bank events and the separation of the Columbia from its floodplain.

Table 6-8. Key and Secondary Limiting Factors and Threats to Recovery of Upper Willamette River Steelhead populations.

Threats	Population	Streams and Rivers within Species Area									West Side Tributaries All Life Stages	Mainstem Willamette (above falls)		Estuary (below Bonneville and Willamette Falls)			Ocean
		Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Kelt		Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult
Harvest	Molalla																
	North Santiam																
	South Santiam																
	Calapooia																
Hatchery	Molalla														4a		
	North Santiam				4c				3						4a		
	South Santiam				4c				3						4a		
	Calapooia				4d										4a		
Hydropower / Flood Control	Molalla														9j		
	North Santiam	10a					1d	2b	7c	2i			10c		5a,5b,7h,10f		
		9d			10d								10d		9j		
		7b													5a,5b,7h,10f		
	South Santiam	10e			10d		1e	2c		2j			10c		9j		
		9e													5a,5b,7h,10f		
Landuse		7d											10d				
	Calapooia												10c		9j		
													10d		5a,5b,7h,10f		
	Molalla	7a			9a	8a									6e,8a,9a,9h,9i		
					10b										5a		
					2a												
Introduced Species	North Santiam	7a			9a	8a						8a			6e,8a,9a,9h,9i		
					10b										5a		
					2a												
	South Santiam	7a			9a	8a						8a			6e,8a,9a,9h,9i		
					10b										5a		
					2a												
Calapooia		7a			9a	8a		2h				8a			6e,8a,9a,9h,9i		
					10b										5a		
					2a												
Molalla																	

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors to recovery of Upper Willamette River steelhead populations

- 1d Mortality at North Santiam hydropower/flood control dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
- 1e Mortality at South Santiam hydropower/flood control dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
- 2b Impaired access to habitat above North Santiam hydropower/flood control dams.
- 2c Impaired access to habitat above South Santiam hydropower/flood control dams.
- 3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- 4c Competition with naturally produced progeny of hatchery summer steelhead.
- 4d Competition with residualized hatchery summer steelhead smolts.
- 5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
- 5b Increased microdetrital inputs due to reservoirs.
- 6b Predation by non-native largemouth bass in Green Peter reservoir.
- 7h Impaired fine sediment recruitment due to dam blockage.
- 8a Impaired physical habitat from past and/or present land use practices (tributaries).
- 10a Elevated flows during spawning and dewatering of redds below North Santiam hydropower/flood control dams.
- 10c Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation
- 10e Elevated flows during spawning and dewatering of redds below the South Santiam hydropower/flood control dams.
- 10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors to recovery of Upper Willamette River steelhead populations

- 2a Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable sized streams.
- 2h Impaired access to habitat above Calapooia dams.
- 2i Impaired downstream passage at North Santiam hydropower/flood control dams.
- 2j Impaired downstream passage at South Santiam hydropower/flood control dams.
- 4a Competition with hatchery fish of all species.
- 6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
- 7a Fine sediment in spawning gravel from past and/or present land use practices.
- 7b Streambed coarsening below North Santiam hydropower/flood control dams due to reduced peak flows.
- 7c Lack of gravel recruitment below North Santiam hydropower/flood control dams due to gravel capture in upstream reservoirs.
- 7d Streambed coarsening below South Santiam hydropower/flood control dams due to reduced peak flows.
- 8a Impaired physical habitat from past and/or present land use practices (mainstem).
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9d Cool water temperatures below North Santiam hydropower/flood control dams impedes development or growth.
- 9e Elevated water temperatures below the South Santiam hydropower/flood control dams.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.
- 10b Insufficient streamflows due to land use related water.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat.

Table 6-9. Effects of Limiting Factors to Recovery of Upper Willamette River Steelhead.

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
Hatchery Management			
<i>Population traits - Hatchery fish interbreeding with wild fish (3)</i>	<i>Winter steelhead: spawners, tributaries (1)</i>	Hatchery fish interbreeding with wild fish results in a risk of altered genetic traits.	Abundance, productivity, diversity
<i>Competition- with hatchery fish of all species (4a)</i>	<i>Winter steelhead: smolts, estuary (2)</i>	Mortality of naturally produced juvenile salmonids which must compete with numerous hatchery fish for limited habitat and food in estuary.	Abundance, productivity, diversity
<i>Competition- with produced progeny of hatchery fish (4c)</i>	<i>Winter steelhead: fry, summer parr, winter parr, tributaries (1)</i>	Competition with naturally produced progeny of hatchery spring Chinook.	Abundance, productivity, diversity
<i>Competition- with residualized hatchery smolts (4d)</i>	<i>Winter steelhead: summer parr, winter parr, tributaries (1)</i>	Competition with residualized hatchery summer steelhead smolts.	Abundance, productivity, diversity
Hydropower/Flood Control Management			
<i>Habitat access- Direct mortality associated with hydropower/flood control dams (1d, 1e)</i>	<i>Winter steelhead: smolts, tributaries (1)</i>	Mortality at N. Santiam, S. Santiam and MF Willamette dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.	Abundance, productivity, diversity, spatial structure
<i>Habitat access- impaired access to habitat above dams (2b, 2c, 2h)</i>	<i>Winter steelhead: returning adults, tributaries- N. Santiam & S. Santiam (1); Calapooia dams (2)</i>	Impaired access to habitat above dams: N. Santiam, S. Santiam, Calapooia	Abundance, productivity, diversity, spatial structure
<i>Habitat access- impaired downstream passage (2i, 2j)</i>	<i>Winter steelhead: kelts, tributaries (2)</i>	Impaired downstream passage at N. Santiam & S. Santiam hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Food web- Reduced macrodetrital inputs (5a)</i>	<i>Winter steelhead: yearlings, estuary (1)</i>	Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.	Abundance, productivity, diversity
<i>Food web- Increased microdetrital inputs (5b)</i>	<i>Winter steelhead: yearlings, estuary (1)</i>	Increased microdetrital inputs due to reservoirs.	Abundance, productivity, diversity
<i>Physical habitat quality- gravel recruitment (7c)</i>	<i>Winter steelhead: spawners, tributaries (2)</i>	Lack of gravel recruitment below N. Santiam hydropower/flood control dams due to gravel capture in upstream reservoirs. Is not considered a problem in S. Santiam because of gravel input from Wiley Cr.	Abundance, productivity

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
<i>Physical habitat quality</i> - Impaired fine sediment routing (7h)	<i>Winter steelhead</i> : yearlings, estuary (1)	Impaired fine sediment recruitment due to dam blockage.	Abundance, productivity, diversity
<i>Physical habitat quality</i> - Streambed coarsening (7b, 7d)	<i>Winter steelhead</i> : eggs and alevins, tributaries (2)	Streambed coarsening below North Santiam and S. Santiam hydropower/flood control dams due to reduced peak flows.	Abundance, productivity
<i>Water quality</i> -Cool water temperatures (9d)	<i>Winter steelhead</i> : eggs, alevins, fry, tributaries (2)	Cool water temperatures below North Santiam hydropower/flood control dams impede development or growth.	Abundance, productivity
<i>Water quality</i> -Elevated water temperatures (9e)	<i>Winter steelhead</i> : eggs and alevins, tributaries (2)	Elevated water temperatures below S. Santiam hydropower/flood control dams resulting in premature hatching and emergence.	Abundance, diversity, and productivity
<i>Water quality</i> -Elevated water temperatures (9j)	<i>Winter steelhead</i> : yearling, estuary (2)	Elevated water temperatures due to mainstem Columbia River reservoir heating.	Abundance, productivity
<i>Hydrograph/water quantity</i> - Elevated flows in N. Santiam (10a, 10e)	<i>Winter steelhead</i> : eggs and alevins, tributaries (1)	Elevated flows during spawning and dewatering of redds below N. Santiam and S. Santiam hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Hydrograph/water quantity</i> - Reduced flows (10c)	<i>Winter steelhead</i> : smolts, mainstem Willamette (1)	Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.	Abundance, productivity
<i>Hydrograph/water quantity</i> - Altered hydrology (10d)	<i>Winter steelhead</i> : fry and parr, tributaries (1); <i>Winter steelhead</i> : parr & smolts, mainstem (2). Molalla fish are not considered to be significantly impacted by Willamette River or Westside tributary conditions because of the Molalla's location. Molalla Spring Chinook and winter steelhead have minimal use of the habitats.	Reduced peak flows decrease channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.	Abundance, productivity, diversity
<i>Hydrograph/water quantity</i> - Altered hydrology (10f)	<i>Winter steelhead</i> : yearling estuary (1)	Altered flows due to hydropower system result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat and sediment transport.	Abundance, diversity, and productivity
<i>Predation</i> - non-native fish (6b)	<i>Winter steelhead</i> : summer parr, winter parr, tributaries (1)	Predation by non-native largemouth bass in Green Peter Reservoir.	Abundance, productivity, diversity, spatial structure
Land Management			
<i>Habitat access</i> : Impaired access (2a)	<i>Winter steelhead</i> : fry, parr, smolts & returning adults, tributaries (2)	Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable-sized streams	Abundance, productivity, diversity, spatial

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
			structure
<i>Physical habitat quality-</i> Fine sediment in spawning gravel (7a)	<i>Winter steelhead:</i> eggs & alevin, tributaries (2)	Fine sediment in spawning gravel from past and/or present land use practices.	Abundance, productivity,
<i>Physical habitat quality-</i> Reduced complexity and impaired stream and watershed function (8a)	<i>Winter steelhead:</i> winter parr, tributaries (1); <i>Winter steelhead:</i> parr and smolts, mainstem (2)	Past and present land practices reduce instream habitat complexity and access to off-channel habitat (removal of large wood from the stream channel, altered riparian conditions, channel straightening, revertments, gravel mining, floodplain connectivity).	Abundance, productivity, distribution, diversity
<i>Habitat access-</i> Reduced habitat access and connectivity (8a)	<i>Winter steelhead:</i> winter parr, tributaries (1); <i>Winter steelhead:</i> parr and smolts, mainstem (2)	Past and present land management practices reduce access to off-channel habitat and floodplain.	Abundance, productivity,
<i>Water quality –</i> temperature (9a)	<i>Winter steelhead:</i> fry and summer parr, tributaries (2)	Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.	Abundance, distribution, diversity, and productivity
<i>Water quality – toxicity</i> (9h, 9i)	<i>Winter steelhead:</i> yearling, estuary (2)	Toxicity due to agricultural, urban and industrial practices.	Abundance, diversity, and productivity
<i>Hydrograph/water</i> <i>quality- water</i> <i>withdrawals (10b)</i>	<i>Winter steelhead:</i> fry & summer parr, tributaries (2)	Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.	Abundance, productivity,
<i>Predation- birds (6e)</i>	<i>Winter steelhead:</i> smolts, estuary (2)	Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.	Abundance, diversity, and productivity

6.2.4 Key Limiting Factors and Threats to Recovery for Molalla Populations of Steelhead and Chinook

This section summarizes limiting factors and threats that are specific to Molalla steelhead and Chinook populations. Table 6-10 identifies the key and secondary limiting factors and threats to recovery of the Molalla populations. Table 6-11 shows the effects of the limiting factors on the different populations and life stages, locations where impacts occur, specific threats, and VSP parameters affected. See section 6.2.1 for a discussion of limiting factors and threats (such as Columbia River harvest impacts and effects from the Columbia River hydro system) that are common to Upper Willamette River Chinook and steelhead populations.

Key threats to recovery of Molalla steelhead and Chinook populations occur at both juvenile and adult life cycle stages, and in all spatial locations except West-side tributaries and the ocean.

Harvest Management

Harvest was only a key threat at the adult life stage of the Molalla Chinook population, within the Molalla basin.

- *Population traits.* Impacts to the Molalla Chinook population involve mortality caused by a catch and release fishery.

Hatchery Management

Hatchery threats exert key adverse effects on Molalla Chinook at the adult spawning life stage.

- *Population traits.* Hatchery Chinook interbreeding with wild Molalla Chinook presents a risk of genetic introgression. About 100,000 Chinook smolts from South Santiam hatchery are released annually into the Molalla. These fish comprise most of the hatchery fish on the spawning grounds. . Few redds have been observed from natural or hatchery fish.
- *Competition.* Summer steelhead represent a risk to the abundance, productivity, spatial structure, and diversity of the Molalla winter steelhead population (NMFS 2004). While no hatchery winter or summer steelhead have been released into the Molalla River since the late 1990s, low densities of summer steelhead spawning have been observed in the mainstem Molalla River, North Fork Molalla River and Abiqua, Cougar and Lost creeks. Studies show adverse effects from non-native summer run steelhead on native winter run steelhead, especially when summer run spawn in the same areas as winter run fish (NMFS 2004).

Hydropower/Flood Control Management

Threats associated with the hydropower/flood control category exert key adverse effects on the fingerling/subyearling life stage of Chinook and on the yearling life stage of steelhead in the estuary. Factors associated with this threat category are discussed in Section 6.2.1.

Land Management

Present or historical land use practices exert key adverse effects on juvenile life history stages of the Molalla steelhead and Chinook populations in the Molalla basin and in the estuary. Land use impacts also exert key adverse effects on the adult life stage of Chinook in the Molalla basin.

- *Water quality.* Elevated water temperatures decrease survival and/or growth of juvenile Chinook and increase prespawning mortality of adult Chinook. High water temperatures are common in the lower Molalla subbasin, and are aggravated by loss of riparian cover, reduced wetland areas, channel simplification, and increased impervious surfaces (WRI 2004). In the Pudding River, low summertime flows contribute to concentrating nonpoint-source runoff (toxics and nutrients) and aggravate naturally higher water temperatures. Water temperatures exceed criteria throughout the Pudding drainage. Many of the tributaries, particularly in the lower subbasin, have elevated water temperatures. Nutrient and toxic runoff from agricultural and urban areas is an issue in the Pudding drainage (WRI 2004).
- *Physical habitat quality.* Impaired physical habitat typically degrades rearing potential for the winter parr life stage of both species. Historical wood removal from streams and riparian harvest has reduced large wood in the channels, though riparian areas in the forested upper subbasin have more conifer trees than in the lower subbasin. Reduced wood in stream channels limits the formation of pools, thus reducing hiding areas for adult fish and restricting the quality and quantity of juvenile rearing habitat. There has also been an extensive loss of wetlands throughout the subbasin. Loss of connectivity to floodplain and wetland habitats has affected juvenile rearing and refuge habitat, particularly in the lower subbasin. Backwater habitats, including pool margins, side channels, and alcoves, are reduced from historical levels (WRI 2004).

Loss of holding pools cause increased prespawning mortality of adult Chinook. The loss of wetland, floodplain and off-channel habitats has also affected the quantity and quality of adult holding areas.

- *Habitat access.* The fish ladder at Silverton's water diversion on Abiqua Creek has an inadequate entrance and is a partial fish passage barrier. Numerous culverts throughout the subbasin restrict juvenile access to rearing and refuge habitat. Unscreened diversions exist on the mainstem Molalla River near Shady Cove. Labish Ditch is another unscreened diversion. Fish passage is also restricted by small dams on Butte, Abiqua, and Silver creeks. While many of these dams are laddered for fish passage, the effectiveness of the fish ladders is unknown (WRI 2004).

Table 6-10. Key and Secondary Limiting Factors and Threats to Recovery of Molalla Spring Chinook and Winter Steelhead.

		Tributaries (Streams and Rivers within Population Area)										West Side Tributaries		Mainstem Willamette (above falls)		Estuary (below Bonneville and Willamette Falls)				Ocean
		Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Kelt	Presmolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult			
Threats	Species																			
Harvest	Chinook																			
	Steelhead																			
Hatchery	Chinook								3						4a					
	Steelhead														4a					
Hydropower/ Flood Control	Chinook													5a,5b,7h,10f 9j						
	Steelhead													5a,5b,7h,10f 9j						
Landuse	Chinook	7a	8a	9a	8a			8b							5a	6e,8a,9a,9h,9i				
				8a				9c												
				10b																
	Steelhead	7a		9a	8a									5a	6e,8a,9a,9h,9i					
	10b																			
				2a											6e,8a,9a,9h,9i					
Introduced Species	Chinook																			
	Steelhead																			

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key and threats and limiting factors

- 3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- 5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
- 5b Increased microdetrital inputs due to reservoirs.
- 7h Impaired fine sediment recruitment due to dam blockage.
- 8a Impaired physical habitat from past and/or present land use practices.
- 8b Loss of holding pools from past and/or present land use practices resulting in increased prespawning mortality.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9c Elevated water temperatures from past and/or present land use practices leading to prespawning mortality.
- 10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary and threats and limiting factors

- 2a Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable sized streams.
- 4a Competition with hatchery fish of all species.
- 6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
- 7a Fine sediment in spawning gravel from past and/or present land use practices.
- 8a Impaired physical habitat from past and/or present land use practices.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.
- 10b Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.

Table 6-11. Effects of Limiting Factors to Recovery of Molalla Spring Chinook and Steelhead.

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
Hatchery Management			
<i>Population traits -</i> Hatchery fish interbreeding with wild fish (3)	<i>Spring Chinook:</i> spawners, tributaries (1)	Hatchery fish interbreeding with wild fish results in a risk of altered genetic traits.	Abundance, productivity, diversity
<i>Competition-</i> with hatchery fish of all species (4a)	<i>Spring Chinook:</i> parr and smolts, estuary (2); <i>Winter steelhead:</i> smolts, estuary (2)	Mortality of naturally produced juvenile salmonids which must compete with numerous hatchery fish for limited habitat and food in estuary.	Abundance, productivity, diversity
Hydropower/Flood Control Management			
<i>Food web-</i> Reduced macrodetrital inputs (5a)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearling, estuary (1)	Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.	Abundance, productivity, diversity
<i>Food web -</i> Increased microdetrital inputs (5b)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearling, estuary (1)	Increased microdetrital inputs due to reservoirs.	Abundance, productivity, diversity
<i>Physical habitat quality-</i> Impaired fine sediment routing (7h)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearlings, estuary (1)	Impaired fine sediment recruitment due to dam blockage.	Abundance, productivity, diversity
<i>Water quality-</i> Elevated water temperatures (9j)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearling, estuary (1)	Elevated water temperatures due to mainstem Columbia reservoir heating.	Abundance, productivity, diversity
<i>Hydrograph/water</i> <i>quantity-</i> Altered hydrology (10f)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearling, estuary (1)	Altered flows due to Columbia hydropower system result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat and sediment transport.	Abundance, diversity, and productivity
Land Management			
<i>Habitat access:</i> Impaired access (2a)	<i>Winter steelhead:</i> fry, parr, smolts & returning adults, tributaries (2)	Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable-sized streams	Abundance, productivity, diversity, spatial structure
<i>Physical habitat quality-</i> Fine sediment in spawning gravel (7a)	<i>Spring Chinook:</i> eggs & alevins, tributaries (2); <i>Winter steelhead:</i> eggs & alevin, tributaries (2)	Fine sediment in spawning gravel from past and/or present land use practices.	Abundance, productivity,
<i>Physical habitat quality-</i> Reduced complexity and impaired stream and watershed function (8a)	<i>Spring Chinook:</i> winter parr, tributaries (1); <i>Winter steelhead:</i> winter parr, tributaries (1); <i>Spring Chinook:</i> fry & summer parr, tributaries (2)	Past and present land practices reduce instream habitat complexity and access to off-channel habitat (removal of large wood from the stream channel, altered riparian conditions, channel straightening, revetments, gravel mining, floodplain connectivity).	Abundance, productivity, distribution, diversity
<i>Habitat access-</i> Reduced habitat access and connectivity (8a)	<i>Spring Chinook:</i> winter parr, tributaries (1); <i>Winter steelhead:</i> winter parr, tributaries (1); <i>Spring Chinook:</i> fry & summer parr, tributaries (2)	Past and present land management practices reduce access to off-channel habitat and floodplain.	Abundance, productivity,
<i>Physical habitat quality-</i> holding pools (8b)	<i>Spring Chinook:</i> returning adults, tributaries (1)	Loss of holding pools from past and/or present land use practices resulting in increased prespawning mortality.	Abundance, productivity,

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
<i>Water quality – temperature (9a)</i>	<i>Spring Chinook</i> : summer parr, tributaries (1); <i>Winter steelhead</i> : fry and summer parr, tributaries (2)	Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.	Abundance, distribution, diversity, and productivity
<i>Water quality – temperature (9c)</i>	<i>Spring Chinook</i> : returning adults, tributaries (1)	Elevated water temperatures from past and/or present land use practices leading to prespawning mortality.	
<i>Water quality – toxicity (9h)</i>	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (2); <i>Winter steelhead</i> : yearling, estuary (2)	Toxicity due to agricultural practices.	Abundance, diversity, and productivity
<i>Water quality – toxicity (9i)</i>	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (2); <i>Winter steelhead</i> : yearling, estuary (2)	Toxicity due to urban and industrial practices.	Abundance, diversity, and productivity
<i>Hydrograph/water quality- water withdrawals (10b)</i>	<i>Spring Chinook</i> : summer parr, tributaries (2); <i>Winter steelhead</i> : fry & summer parr, tributaries (2)	Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.	Abundance, productivity,
<i>Predation- birds (6e)</i>	<i>Spring Chinook</i> : parr & smolts, estuary (2); <i>Winter steelhead</i> : smolts, estuary (2)	Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.	Abundance, diversity, and productivity

6.2.5 Key Limiting Factors and Threats to Recovery for North Santiam Populations of Steelhead and Chinook

This section summarizes limiting factors and threats that are specific to North Santiam steelhead and Chinook populations. Table 6-12 identifies the key and secondary limiting factors and threats to recovery of the North Santiam populations. Table 6-13 shows the effects of the limiting factors on the different populations and life stages, locations where impacts occur, specific threats, and VSP parameters affected. See section 6.2.1 for a discussion of limiting factors and threats (such as Columbia River harvest impacts and effects from the Columbia River hydro system) that are common to Upper Willamette River Chinook and steelhead populations.

Key threats to the recovery of North Santiam steelhead and Chinook occur throughout their life cycle and in all spatial areas except the ocean and in West-side tributaries to the Willamette. Harvest was not a key threat at any life stage of North Santiam steelhead and Chinook populations.

Hatchery Management

Hatchery threats exert key adverse effects on North Santiam steelhead and Chinook populations at the adult life stage for Chinook and at both juvenile and adult life stages for steelhead.

- *Competition.* Impacts related to this threat category involve 1) competition between juvenile North Santiam steelhead and naturally produced progeny of hatchery summer steelhead; and 2) competition between juvenile North Santiam steelhead and residual hatchery summer steelhead. Natural production by non-native summer steelhead is a risk to the viability of the South Santiam winter steelhead population (NMFS 2004). Hatchery summer steelhead smolts from South Santiam hatchery stock are released in the North Santiam basin. This hatchery stock was introduced into the Willamette Basin from Skamania stock and is not part of the Upper Willamette River ESU. Not all of the adult summer steelhead are harvested by anglers or removed at the Minto trap. Summer steelhead have been observed spawning in the mainstem North Santiam River, Rock Creek, Mad Creek, Elkhorn Creek, and Sinker Creek. The North Santiam River had the highest densities of summer steelhead redds observed in any of the winter steelhead populations in the ESU. Studies in the Clackamas River have shown adverse effects from non-native Skamania summer steelhead on native winter steelhead because the summer run spawn earlier and can gain a competitive advantage once the progeny hatch and rear in the stream (citation).
- *Population traits.* There is a risk of genetic introgression resulting from interbreeding of naturally produced fish (steelhead and Chinook) with hatchery fish.

Hydropower/Flood Control Management

Threats associated with the Hydropower/flood control category exert key adverse effects on multiple life stages of North Santiam steelhead and Chinook populations within the basin; the steelhead-smolt life stage in the mainstem Willamette; and also affect the fingerling/subyearling and yearling life stages of Chinook in the estuary. Limiting factors associated with hydropower/flood control in the North Santiam basin are summarized below. Section 6.1.2

discusses related impacts from the Columbia system.

- *Hydrograph/water quantity.* Detroit and Big Cliff dams have changed flow regimes in the North Santiam. Increased fall flows at Detroit and Big Cliff dams may allow spawning in areas that are then dewatered during active flood control operations (WRI 2004).
- *Physical habitat quality.* A reduction in the frequency and magnitude of peak flows has caused a reduction of channel complexity and diversity of rearing habitat. Modification of the flow regime has led to changes in the delivery and transport of large wood in the river and tributaries, modified gravel deposition, reduced pool frequency and depth, and minimized hiding cover for adult and juvenile fish (WRI 2004).
- *Habitat access.* Mortality of Chinook juveniles caused by downstream passage through turbines or not being unable to locate downstream passage.
- *Habitat access.* Detroit and Big Cliff dams are complete barriers to adult migration and block access to an estimated 71% of the historical production area for spring Chinook and block access by winter steelhead to historical spawning and rearing areas (WRI 2004). Minto Dam also blocks upstream fish movement.
- *Water quality.* Detroit and Big Cliff dams have changed water temperature patterns. Compared to historical conditions, water temperatures in the river below the dams are cooler in the summer and warmer in the fall and winter, which affects the upstream distribution of spring Chinook adults, alters the timing of spawning, shortens the period of egg incubation and causes fry to emerge earlier (WRI 2004).

Land Management

Present or historical land use practices exert key adverse effects on several juvenile life history stages of North Santiam steelhead and Chinook populations in the basin and in the estuary. Limiting factors associated with this threat category include:

- *Water quality.* Land use practices contribute to elevated water temperatures, which cause decreased survival and/or growth of juveniles, as well as prespawning mortality.
- *Hydrology/water quantity.* During low flow months (July through October), domestic water use, combined with irrigation withdrawals in the lower elevations of the watershed, may significantly reduce stream flows. In 1990, 55% of the population of Marion County obtained its water supply from the North Santiam River. The communities of Idanha, Gates, Mill City, Stayton, Salem, Turner and Jefferson all divert their supplies from the lower or middle reach of the river (or in the case of Jefferson, just below the confluence of the North and South Santiam Rivers) (Snyder, et al. 2002).
- *Physical habitat quality.* Impaired physical habitat has degraded rearing potential for winter parr life stage of juveniles. The lower portion of the subbasin contains only 25% of the original extent of floodplain forest, and there has been significant loss of wetland, floodplain, and off-channel habitats and associated habitat complexity. The floodplain is not inundated

frequently; reduced over-bank flow and side channel connectivity limit rearing and refuge habitat (WRI 2004).

Reaches of the North Santiam River below Detroit and Big Cliff dams have limited large wood, reducing the formation of pools and side channels, and the ability to capture spawning gravels. Reduced recruitment of large wood has limited creation of new gravel bars, resulting in a decrease in cool water rearing habitats. Limited wood also has reduced hiding areas for adult fish and restricted the quality and quantity of juvenile rearing habitat (WRI 2004).

- **Habitat access.** Upper Bennett Dam (RM 31.5) and lower Bennett Dam (RM 29) impair adult fish access to habitat above the dams. Other partial barriers included unscreened diversions, SWCD power and irrigation canals, Salem ditch, Sidney ditch, and road culverts (WRI 2004).

Table 6-12. Key and Secondary Limiting Factors and Threats to Recovery of North Santiam Spring Chinook and Winter Steelhead.

Threats	Species	Tributaries (Streams and Rivers within Population Area)									West Side Tributaries	Mainstem Willamette (above falls)		Estuary (below Bonneville and Willamette Falls)			Ocean
		Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Kelt	Presmolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult
Harvest	Chinook																
	Steelhead																
Hatchery	Chinook				4b				3					4a			
					6c												
	Steelhead				4c				3						4a		
					4d												
Hydropower/ Flood Control	Chinook	9b			10d		1d	2b	7c			10d		5a,5b,7h,10f			
		7b						2k						9j			
	Steelhead	10a			10d		1d	2b	7c	2i			10c		5a,5b,7h,10f		
		9d															
		7b										10d			9j		
Landuse	Chinook			8a	8a	8a		2f			8a	8a		5a			
				9a										6e,8a,9a,9h,9i			
	Steelhead	7a		9a	10b	8a						8a		5a			
														6e,8a,9a,9h,9i			
Introduced Species	Chinook																
	Steelhead																

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors

- 1d Mortality at North Santiam hydropower/flood control dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
- 2b Impaired access to habitat above North Santiam hydropower/flood control dams.
- 2f Impaired access to habitat above Upper and Lower Bennett dams.
- 3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- 4c Competition with naturally produced progeny of hatchery summer steelhead.
- 4d Competition with residualized hatchery summer steelhead smolts.
- 5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
- 5b Increased microdetrital inputs due to reservoirs.
- 7h Impaired fine sediment recruitment due to dam blockage.
- 8a Impaired physical habitat from past and/or present land use practices.

- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9b Elevated water temperatures below the North Santiam hydropower/flood control dams resulting in premature hatching and emergence.
- 10a Elevated flows during spawning and dewatering of redds below North Santiam hydropower/flood control dams.
- 10c Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.
- 10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors

- 2a Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable sized streams.
- 2i Impaired downstream passage at North Santiam hydropower/flood control dams.
- 2k Prespawning mortality due to crowding below North Santiam hydropower/flood control dams.
- 4a Competition with hatchery fish of all species.
- 4b Competition with naturally produced progeny of hatchery spring Chinook.
- 6c Predation by hatchery summer steelhead smolts.
- 6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
- 7a Fine sediment in spawning gravel from past and/or present land use practices.
- 7b Streambed coarsening below North Santiam hydropower/flood control dams due to reduced peak flows.
- 7c Lack of gravel recruitment below North Santiam hydropower/flood control dams due to gravel capture in upstream reservoirs.
- 8a Impaired physical habitat from past and/or present land use practices.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9d Cool water temperatures below North Santiam hydropower/flood control dams impedes development or growth.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.
- 10b Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

Table 6-13. Effects of Limiting Factors to Recovery of North Santiam Chinook and Steelhead.

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
Hatchery Management			
<i>Population traits -</i> Hatchery fish interbreeding with wild fish (3)	<i>Spring Chinook:</i> spawners, tributaries (1); <i>Winter steelhead:</i> spawners, tributaries (1)	Hatchery fish interbreeding with wild fish results in a risk of altered genetic traits.	Abundance, productivity, diversity
<i>Competition-</i> with hatchery fish of all species (4a)	<i>Spring Chinook:</i> parr & smolts, estuary (2); <i>Winter steelhead:</i> smolts, estuary (2)	Mortality of naturally produced juvenile salmonids which must compete with numerous hatchery fish for limited habitat and food in estuary.	Abundance, productivity, diversity
<i>Competition-</i> with produced progeny of hatchery fish (4b, 4c)	<i>Winter steelhead:</i> fry, summer parr, winter parr, tributaries (1); <i>Spring</i> <i>Chinook:</i> fry, summer parr, winter parr, tributaries (2)	Competition with naturally produced progeny of hatchery summer steelhead and spring Chinook.	Abundance, productivity, diversity
<i>Competition-</i> with residualized hatchery smolts (4d)	<i>Winter steelhead:</i> summer parr, winter parr, tributaries (1)	Competition with residualized hatchery summer steelhead smolts.	Abundance, productivity, diversity
<i>Predation-</i> hatchery smolts (6c)	<i>Spring Chinook:</i> fry, summer parr, winter parr, tributaries 2)	Predation by hatchery summer steelhead smolts.	Abundance, productivity, diversity
Hydropower/Flood Control Management			
<i>Habitat Access-</i> Direct mortality associated with hydropower/flood control dams (1d)	<i>Spring Chinook:</i> smolts, tributaries (1); <i>Winter steelhead:</i> smolts, tributaries (1)	Mortality at North Santiam hydropower/flood control dams due to direct mortality in the turbines or smolts being trapped in the reservoirs.	Abundance, productivity, diversity, spatial structure
<i>Habitat access-</i> above North Santiam dams (2b)	<i>Spring Chinook:</i> returning adults, tributaries (1); <i>Winter steelhead:</i> returning adults, tributaries (1)	Impaired access to habitat above North Santiam hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Habitat access-</i> impaired downstream passage (2i)	<i>Winter steelhead:</i> kelts, tributaries (2)	Impaired downstream passage at North Santiam hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Population traits:</i> prespawning mortality (2k)	<i>Spring Chinook:</i> returning adults, tributaries (2)	Prespawning mortality due to crowding below North Santiam hydropower/flood control dams.	Abundance, productivity
<i>Food web-</i> Reduced macrodetrital inputs (5a)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearlings, estuary (1)	Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.	Abundance, productivity, diversity
<i>Food web-</i> Increased microdetrital inputs (5b)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i>	Increased microdetrital inputs due to reservoirs.	Abundance, productivity,

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
	yearlings, estuary (1)		diversity
<i>Physical habitat quality</i> -gravel recruitment (7c)	<i>Spring Chinook</i> : spawners, tributaries (2); <i>Winter steelhead</i> : spawners, tributaries (2)	Lack of gravel recruitment below North Santiam hydropower/flood control dams due to gravel capture in upstream reservoirs.	Abundance, productivity
<i>Physical habitat quality</i> -Impaired fine sediment routing (7h)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead</i> : yearlings, estuary (1)	Impaired fine sediment recruitment due to dam blockage.	Abundance, productivity, diversity
<i>Physical habitat quality</i> -Streambed coarsening (7b, 7d)	<i>Spring Chinook</i> : eggs and alevins, tributaries (2); <i>Winter steelhead</i> : eggs and alevins, tributaries (2)	Streambed coarsening below North Santiam hydropower/flood control dams due to reduced peak flows.	Abundance, productivity
<i>Water quality</i> -Cool water temperatures (9d)	<i>Winter steelhead</i> : eggs, alevins, fry, tributaries (2)	Cool water temperatures below North Santiam hydropower/flood control dams impede development or growth.	Abundance, productivity
<i>Water quality</i> -Elevated water temperatures (9b)	<i>Spring Chinook</i> : eggs and alevins, tributaries (1)	Elevated water temperatures below North Santiam hydropower/flood control dams resulting in premature hatching and emergence.	Abundance, diversity, and productivity
<i>Water quality</i> -Elevated water temperatures (9j)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (2); <i>Winter steelhead</i> : yearling, estuary (2)	Elevated water temperatures due to mainstem Columbia River reservoir heating.	Abundance, productivity
<i>Hydrograph/water quantity</i> - Elevated flows (10a)	<i>Winter steelhead</i> : eggs and alevins, tributaries (1)	Elevated flows during spawning and dewatering of redds below North Santiam hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Hydrograph/water quantity</i> - Reduced flows (10c)	<i>Winter steelhead</i> : smolts, mainstem Willamette (1)	Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.	Abundance, productivity
<i>Hydrograph/water quantity</i> - Altered hydrology (10d)	<i>Spring Chinook</i> : fry & parr, tributaries (1); <i>Winter steelhead</i> : fry & parr, tributaries (1); <i>Spring Chinook</i> : parr & smolts, mainstem (2); <i>Winter steelhead</i> : parr & smolts, mainstem (2).	Reduced peak flows decrease channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.	Abundance, productivity, diversity
<i>Hydrograph/water quantity</i> - Altered hydrology (10f)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead</i> : yearling estuary (1)	Altered flows due to hydropower system result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat and sediment transport.	Abundance, diversity, and productivity
Land Management			
<i>Habitat access</i> : Impaired access (2a)	<i>Winter steelhead</i> : fry, parr, smolts & returning adults, tributaries (2)	Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable-sized streams	Abundance, productivity, diversity, spatial

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
			structure
<i>Habitat access-</i> above Upper and Lower Bennett dams (2f)	<i>Spring Chinook:</i> returning adults, tributaries (1)	Impaired access to habitat above Upper and Lower Bennett dams.	Abundance, productivity, diversity, spatial structure
<i>Physical habitat quality-</i> Fine sediment in spawning gravel (7a)	<i>Winter steelhead:</i> eggs & alevin, tributaries (2)	Fine sediment in spawning gravel from past and/or present land use practices.	Abundance, productivity,
<i>Physical habitat quality-</i> Reduced complexity and impaired stream and watershed function (8a)	<i>Spring Chinook & Winter steelhead:</i> winter parr, tributaries (1); <i>Spring Chinook:</i> fry & summer parr, tributaries (2), <i>Spring Chinook:</i> pre-smolts, Westside tributaries (2); <i>Spring Chinook & Winter steelhead:</i> parr and smolts, mainstem (2)	Past and present land practices reduce instream habitat complexity and access to off-channel habitat (removal of large wood from the stream channel, altered riparian conditions, channel straightening, revertsments, gravel mining, floodplain connectivity).	Abundance, productivity, distribution, diversity
<i>Habitat access-</i> Reduced habitat access and connectivity (8a)	<i>Spring Chinook & Winter steelhead:</i> winter parr, tributaries (1); <i>Spring Chinook:</i> fry & summer parr, tributaries (2), <i>Spring Chinook:</i> pre-smolts, Westside tributaries (2); <i>Spring Chinook & Winter steelhead:</i> parr and smolts, mainstem (2)	Past and present land management practices reduce access to off-channel habitat and floodplain.	Abundance, productivity,
<i>Water quality –</i> temperature (9a)	<i>Spring Chinook:</i> summer parr, tributaries (1); <i>Winter steelhead:</i> fry and summer parr, tributaries (2)	Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.	Abundance, distribution, diversity, and productivity
<i>Water quality –</i> toxicity (9h, 9i)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (2); <i>Winter steelhead:</i> yearling, estuary (2)	Toxicity due to agricultural, urban and industrial practices.	Abundance, diversity, and productivity
<i>Hydrograph/water quality-</i> water withdrawals (10b)	<i>Winter steelhead:</i> fry & summer parr, tributaries (2)	Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.	Abundance, productivity
<i>Predation-</i> birds (6e)	<i>Spring Chinook:</i> parr & smolts, estuary (2); <i>Winter steelhead:</i> smolts, estuary (2)	Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.	Abundance, diversity, and productivity

6.2.6 Key Limiting Factors and Threats to Recovery for South Santiam Populations of Steelhead and Chinook

This section summarizes limiting factors and threats that are specific to South Santiam steelhead and Chinook populations. Table 6-14 identifies the key and secondary limiting factors and threats to recovery of the South Santiam populations. Table 6-15 shows the effects of the limiting factors on the different populations and life stages, locations where impacts occur, specific threats, and VSP parameters affected. See section 6.2.1 for a discussion of limiting factors and threats (such as Columbia River harvest impacts and effects from the Columbia River hydro system) that are common to Upper Willamette River Chinook and steelhead populations.

Key threats to the recovery of South Santiam steelhead and Chinook occur throughout their life cycle and in all spatial areas except the ocean and in West-side tributaries to the Willamette. Harvest was not a key threat at any life stage of South Santiam steelhead and Chinook populations.

Hatchery Management

Hatchery threats exert key adverse effects on South Santiam steelhead and Chinook populations at the adult spawning life stage for Chinook and at both juvenile and adult spawning life stages for steelhead. Limiting factors associated with this threat include:

- *Competition.* Competition between juvenile South Santiam steelhead and naturally produced progeny of non-native hatchery summer steelhead. . Natural production by non-native summer steelhead is a risk to the viability of the South Santiam winter steelhead population (NMFS 2004). Hatchery summer steelhead smolts from South Santiam hatchery stock are released in the basin. This hatchery stock was introduced into the Willamette Basin from Skamania stock and is not part of the Upper Willamette River ESU. Not all of the adult summer steelhead are harvested by anglers or removed at the Foster trap. Summer steelhead have been observed spawning in the mainstem South Santiam River, Wiley, Crabtree, and Thomas Creeks. Studies in the Clackamas River have shown adverse effects from non-native Skamania summer steelhead on native winter steelhead because the summer run spawn earlier and can gain a competitive advantage once the progeny hatch and rear in the stream (citation).
- *Population traits.* The risk of genetic introgression resulting from interbreeding of naturally produced fish (steelhead and Chinook) with hatchery fish. Over the last 20 years, high proportions of hatchery spring Chinook have been interbreeding with the natural population below Foster Dam. The proportions of spring Chinook with various life history characteristics are different than the historic populations in the Willamette Basin. Most hatchery produced juveniles are released as age-1 smolts in the spring, whereas a more continuous migration of naturally produced smolts through the fall and spring periods was observed in the historic populations (Willis, et al. 1995, cited in NMFS 2004). Hatchery Chinook return at an earlier age than the historic populations. Most of the returns now are age-4 fish instead of age-5 (Willis, et al. 1995, cited in NMFS 2004). It is unknown if younger adults is the result of genetic changes as the result of hatchery operations or fisheries, or simply the result of releasing larger smolts than occurred naturally.

Hydropower/Flood Control Management

Threats associated with the hydropower/flood control category exert key adverse effects on multiple life stages of South Santiam steelhead and Chinook populations within the basin; the steelhead-smolt life stage in the mainstem Willamette; and also affect the fingerling/subyearling and yearling life stages in the estuary. Limiting factors associated with hydro-related threats in the South Santiam basin are summarized below. Factors associated with hydro-related threats in the Columbia River and/or else where in the Willamette system are discussed in Section 6.1.2.

- *Hydrograph/water quantity.* Flow fluctuations below Green Peter Dam now occur at rates rapid enough to entrap and strand juvenile anadromous fish. Elevated flows during spawning and reduced flows during egg incubation can dewatering redds.
- *Physical habitat quality.* Changes in the frequency and magnitude of high flow events below Green Peter and Foster dams have caused a reduction of channel complexity and diversity of rearing habitat. The frequency of large magnitude flows is not sufficient to create and maintain channel complexity and provide nutrient, organic matter, and sediment inputs from floodplain areas. The floodplain is not inundated frequently, which results in reductions in over-bank flow and side-channel connectivity, nutrient exchange, sediment exchange, and flood refugia for fish. Reduced pool frequency, depth, and cover have affected the quality of adult habitat in the river and tributaries. The dams also block transport of large wood from 50% of the subbasin (U.S. Army Corps of Engineers, 2001). Limited wood in the river and tributaries has affected the quality of pools and backwater habitats (WRI 2004).
- *Water quality.* Green Peter and Foster dams have changed flow regimes and water temperature patterns. Compared to historical conditions, water temperatures in the river below the dams are cooler in the summer and warmer in the fall and winter, which alters the timing of spawning, and affects the period of egg incubation (USACE 2001, cited in WRI 2004). Maximum temperatures for incubation emergence have been exceeded in the lower South Santiam River. Water temperatures in the South Santiam River exceed water quality criteria for summer maximums for juvenile rearing and migration. Water temperatures in the South Santiam River have also exceeded water quality criteria for summer maximum adult migration (WRI 2004).
- *Habitat access.* Mortality of steelhead and Chinook juveniles, and steelhead kelts occurs during downstream passage through turbines or because they are not able to locate downstream passage.
- *Habitat access.* Green Peter and Foster dams block or limit access to an estimated 85% of the historical production area for spring Chinook and limit access to historical winter steelhead spawning and rearing areas. While Green Peter and Foster Dams are equipped with fish passage facilities, there are adult fish passage problems at both dams.

Land Management

Present or historical land use practices exert key adverse effects on several juvenile life history stages of South Santiam steelhead and Chinook populations in the basin and in the estuary. Limiting factors related to this threat category include:

- *Water quality.* Water temperatures exceed criteria in the South Santiam River and many of the tributaries. In general, water temperatures are lower in the forested upper subbasin. High water temperatures in the lower subbasin are aggravated by loss of riparian cover, reduced wetland areas, and channel simplification (E&S 2000). Elevated water temperatures decrease survival and/or growth of juveniles, as well as increase prespawning mortality of adults.
- *Physical habitat quality.* Impaired physical habitat has resulted in degraded rearing potential for winter parr life stage of juveniles. Mature riparian forests make up a very small proportion of the floodplain and riparian vegetation along the river and tributaries in the lower basin, particularly in areas where there is the largest amount of agricultural use. Riparian conditions are better in the upper basin than in the lower, but levels of mature and old-growth coniferous forests are reduced (USACE 2001, cited in WRI 2004). Past management of riparian areas and stream cleaning practices have led to reduced large wood in streams.
- *Habitat access.* The 8-foot-tall Lebanon Dam at RM 21 impairs fish passage. This dam is equipped with several new fish ladders that allow passage of adult fish, but the dam may still results in some migration delay or injury as adult fish seek the entrances. A number of irrigation diversions on the lower tributaries of Crabtree and Thomas creeks also pose migration barriers to adult spring Chinook (such as the Lacombe Dam at RM 25 of Crabtree Creek) due to the use of push-up dams to capture water during low late summer flows (E&S 2000). Numerous partial and complete fish passage barriers at culverts on tributary streams limit juvenile upstream movement into rearing and refuge habitat.
- *Hydrograph/water quantity.* Flow reductions associated with diversions for irrigation, domestic, and industrial water uses contribute to low flow conditions in the river and its tributaries, particularly in late summer and early fall.

Table 6-14. Key and Secondary Limiting Factors and Threats to Recovery of South Santiam Spring Chinook and Winter Steelhead.

		Tributaries (Streams and Rivers within Population Area)									West Side Tributaries	Mainstem Willamette (above falls)	Estuary (below Bonneville and Willamette Falls)				Ocean
Threats	Species	Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Kelt	Presmolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult
Harvest	Chinook																
	Steelhead																
Hatchery	Chinook			4b					3					4a			
				6c													
	Steelhead			4c					3						4a		
Hydropower/ Flood Control				4d													
	Chinook	9e		10d			1e	2c				10d		5a,5b,7h,10f			
		7d						2l			9j						
	Steelhead	10e		10d			1e	2c	2j		10c		5a,5b,7h,10f				
		9e										9j					
7d												10d		9j			
Landuse	Chinook			8a	8a	8a		2g			8a	8a	8a	5a			
				9a										6e,8a,9a,9h,9i			
	Steelhead	7a		9a	8a						8a			5a			
			10b					6e,8a,9a,9h,9i									
Introduced Species	Chinook				6b												
	Steelhead				6b												

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors

- 1e Mortality at South Santiam hydropower/flood control dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
- 2c Impaired access to habitat above South Santiam hydropower/flood control dams.
- 2g Impaired access to habitat above Lebanon dam.
- 3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- 4c Competition with naturally produced progeny of hatchery summer steelhead.
- 4d Competition with residualized hatchery summer steelhead smolts.
- 5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
- 5b Increased microdetrital inputs due to reservoirs.
- 6b Predation by non-native largemouth bass in Green Peter reservoir.
- 7h Impaired fine sediment recruitment due to dam blockage.
- 8a Impaired physical habitat from past and/or present land use practices.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9e Altered water temperatures below the South Santiam hydropower/flood control dams resulting in premature hatching and emergence of Chinook and delayed hatching and emergence of winter steelhead.
- 10c Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.
- 10e Elevated flows during spawning and dewatering of redds below the South Santiam hydropower/flood control dams.
- 10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors

- 2a Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable sized streams.
- 2j Impaired downstream passage at South Santiam hydropower/flood control dams.
- 2l Prespawning mortality due to crowding below South Santiam hydropower/flood control dams.

- 4a Competition with hatchery fish of all species.
- 4b Competition with naturally produced progeny of hatchery spring Chinook.
- 6c Predation by hatchery summer steelhead smolts.
- 6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
- 7a Fine sediment in spawning gravel from past and/or present land use practices.
- 7d Streambed coarsening below South Santiam hydropower/flood control dams due to reduced peak flows.
- 8a Impaired physical habitat from past and/or present land use practices.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9e Elevated water temperatures below the South Santiam hydropower/flood control dams resulting in premature hatching and emergence.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.
- 10b Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

Table 6-15. Effects of Limiting Factors to Recovery of South Santiam Chinook and Steelhead.

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
Hatchery Management			
<i>Population traits -</i> Hatchery fish interbreeding with wild fish (3)	<i>Spring Chinook:</i> spawners, tributaries (1); <i>Winter steelhead:</i> spawners, tributaries (1)	Hatchery fish interbreeding with wild fish results in a risk of altered genetic traits.	Abundance, productivity, diversity
<i>Competition-</i> with hatchery fish of all species (4a)	<i>Spring Chinook:</i> parr & smolts, estuary (2); <i>Winter steelhead:</i> smolts, estuary (2)	Mortality of naturally produced juvenile salmonids which must compete with numerous hatchery fish for limited habitat and food in estuary.	Abundance, productivity, diversity
<i>Competition-</i> with progeny of hatchery fish (4b, 4c)	<i>Winter steelhead:</i> fry, summer parr, winter parr, tributaries (1); <i>Spring</i> <i>Chinook:</i> fry, summer parr, winter parr, tributaries (2)	Competition with naturally produced progeny of hatchery summer steelhead and spring Chinook.	Abundance, productivity, diversity
<i>Competition-</i> with residualized hatchery smolts (4d)	<i>Winter steelhead:</i> summer parr, tributaries (1)	Competition with residualized hatchery summer steelhead smolts.	Abundance, productivity, diversity
<i>Predation-</i> hatchery smolts (6c)	<i>Spring Chinook:</i> fry, summer parr, tributaries 2)	Predation by hatchery summer steelhead smolts.	Abundance, productivity, diversity
Hydropower/Flood Control Management			
<i>Habitat access-</i> Direct mortality associated with hydropower/flood control dams (1e)	<i>Spring Chinook:</i> smolts, tributaries (1); <i>Winter steelhead:</i> smolts, tributaries (1)	Mortality at South Santiam hydropower/flood control dams due to direct mortality in the turbines or smolts being trapped in the reservoirs M	Abundance, productivity, diversity, spatial structure
<i>Habitat access-</i> above South Santiam dams (2b)	<i>Spring Chinook:</i> returning adults, tributaries (1); <i>Winter steelhead:</i> returning adults, tributaries (1)	Impaired access to habitat above South Santiam hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Habitat access-</i> impaired downstream passage (2j)	<i>Winter steelhead:</i> kelts, tributaries (2)	Impaired downstream passage at South Santiam hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Population traits:</i> prespawning mortality (2l)	<i>Spring Chinook:</i> returning adults, tributaries (2)	Prespawning mortality due to crowding below South Santiam hydropower/flood control dams.	Abundance, productivity
<i>Food web-</i> Reduced macrodetrital inputs (5a)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearlings, estuary (1)	Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.	Abundance, productivity, diversity
<i>Food web-</i> Increased microdetrital inputs (5b)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i>	Increased microdetrital inputs due to reservoirs.	Abundance, productivity,

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
	yearlings, estuary (1)		diversity
<i>Physical habitat quality</i> - Impaired fine sediment routing (7h)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead</i> : yearlings, estuary (1)	Impaired fine sediment recruitment due to dam blockage.	Abundance, productivity, diversity
<i>Physical habitat quality</i> - Streambed coarsening (7d)	<i>Spring Chinook</i> : eggs and alevins, tributaries (2); <i>Winter steelhead</i> : eggs and alevins, tributaries (2)	Streambed coarsening below South Santiam hydropower/flood control dams due to reduced peak flows.	Abundance, productivity, diversity
<i>Water quality</i> -Altered water temperatures (9e)	<i>Spring Chinook</i> : eggs and alevins, tributaries (1); <i>Winter steelhead</i> : eggs & alevins, tributaries (2)	Altered water temperatures below South Santiam hydropower/flood control dams resulting in premature hatching and emergence of Chinook and delayed hatching and emergence of winter steelhead.	Abundance, diversity, and productivity
<i>Water quality</i> -Elevated water temperatures (9j)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (2); <i>Winter steelhead</i> : yearling, estuary (2)	Elevated water temperatures due to mainstem Columbia River reservoir heating.	Abundance, productivity, diversity
<i>Hydrograph/water quantity</i> - Elevated flows (10e)	<i>Winter steelhead</i> : eggs and alevins, tributaries (1)	Elevated flows during spawning and dewatering of redds below South Santiam hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Hydrograph/water quantity</i> - Reduced flows (10c)	<i>Winter steelhead</i> : smolts, mainstem Willamette (1)	Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.	Abundance, productivity
<i>Hydrograph/water quantity</i> - Altered hydrology (10d)	<i>Spring Chinook</i> : fry & parr, tributaries (1); <i>Winter steelhead</i> : fry & parr, tributaries (1); <i>Spring Chinook</i> : parr & smolts, mainstem (2); <i>Winter steelhead</i> : parr & smolts, mainstem (2).	Reduced peak flows decrease channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.	Abundance, productivity, diversity
<i>Hydrograph/water quantity</i> - Altered hydrology (10f)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead</i> : yearling estuary (1)	Altered flows due to Columbia River hydropower system result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat and sediment transport.	Abundance, diversity, and productivity
<i>Predation</i> - non-native fish (6b)	<i>Spring Chinook</i> : summer parr & winter parr, tributaries (1); <i>Winter steelhead</i> : summer parr, winter parr, tributaries (1)	Predation by non-native largemouth bass in Green Peter Reservoir.	Abundance, productivity, diversity, spatial structure
Land Management			
<i>Habitat access</i> - above Lebanon Dam (2g)	<i>Spring Chinook</i> : returning adults, tributaries (1)	Impaired access to habitat above Lebanon Dam.	Abundance, productivity, diversity, spatial

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
			structure
<i>Habitat access:</i> Impaired access (2a)	<i>Winter steelhead:</i> fry, parr, smolts & returning adults, tributaries (2)	Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable-sized streams	Abundance, productivity, diversity, spatial structure
<i>Physical habitat quality-</i> Fine sediment in spawning gravel (7a)	<i>Winter steelhead:</i> eggs & alevin, tributaries (2)	Fine sediment in spawning gravel from past and/or present land use practices.	Abundance, productivity,
<i>Physical habitat quality-</i> Reduced complexity and impaired stream and watershed function (8a)	<i>Spring Chinook & Winter steelhead:</i> winter parr, tributaries (1); <i>Spring Chinook:</i> fry & summer parr, tributaries (2), <i>Spring Chinook:</i> pre-smolts, Westside tributaries (2); <i>Spring Chinook & Winter steelhead:</i> parr and smolts, mainstem (2)	Past and present land practices reduce instream habitat complexity and access to off-channel habitat (removal of large wood from the stream channel, altered riparian conditions, channel straightening, revetments, gravel mining, floodplain connectivity).	Abundance, productivity, distribution, diversity
<i>Habitat access-</i> Reduced habitat access and connectivity (8a)	<i>Spring Chinook & Winter steelhead:</i> winter parr, tributaries (1); <i>Spring Chinook:</i> fry & summer parr, tributaries (2), <i>Spring Chinook:</i> pre-smolts, Westside tributaries (2); <i>Spring Chinook & Winter steelhead:</i> parr and smolts, mainstem (2)	Past and present land management practices reduce access to off-channel habitat and floodplain.	Abundance, productivity
<i>Water quality –</i> temperature (9a)	<i>Spring Chinook:</i> summer parr, tributaries (1); <i>Winter steelhead:</i> fry and summer parr, tributaries (2)	Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.	Abundance, distribution, diversity, and productivity
<i>Water quality –</i> toxicity (9h, 9i)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (2); <i>Winter steelhead:</i> yearling, estuary (2)	Toxicity due to agricultural, urban and industrial practices.	Abundance, diversity, and productivity
<i>Hydrograph/water</i> <i>quality-</i> water withdrawals (10b)	<i>Winter steelhead:</i> fry & summer parr, tributaries (2)	Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.	Abundance, productivity
<i>Predation-</i> birds (6e)	<i>Spring Chinook:</i> parr & smolts, estuary (2); <i>Winter steelhead:</i> smolts, estuary (2)	Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.	Abundance, diversity, and productivity

6.2.7 Key Limiting Factors and Threats to Recovery for Calapooia Populations of Steelhead and Chinook

This section summarizes limiting factors and threats that are specific to Calapooia steelhead and Chinook populations. Table 6-16 identifies the key and secondary limiting factors and threats to recovery of the Calapooia populations. Table 6-17 shows the effects of the limiting factors on the different populations and life stages, locations where impacts occur, specific threats, and VSP parameters affected. See section 6.2.1 for a discussion of limiting factors and threats (such as Columbia River harvest impacts and effects from the Columbia River hydro system) that are common to Upper Willamette River Chinook and steelhead populations.

Key threats to recovery of Calapooia steelhead and Chinook populations occur at both juvenile and adult stages, and in all spatial locations except West-side tributaries and the ocean. Harvest was not a key threat at the any life stage for Calapooia steelhead or Chinook populations.

Hatchery Management

Hatchery threats exert key adverse effects on Calapooia Chinook at the adult spawning life stage.

- *Population traits.* Impacts related to this threat category involve the risk of genetic introgression resulting from interbreeding with hatchery Chinook. There is not a hatchery program in the Calapooia basin. South Santiam stock spring Chinook from South Santiam hatchery have been outplanted in the Calapooia to bolster the population because of the extremely low number of adults returning.

Land Management

Present or historical land use practices exert key adverse effects on juvenile life history stages of the Calapooia steelhead and Chinook populations in the Calapooia basin and in the estuary. Land use impacts also exert key adverse effects on the adult life stage of Chinook in the Calapooia basin. Limiting factors in the Calapooia basin include:

- *Water quality.* Naturally low flows in the basin are aggravated by water withdrawals, which increase water temperatures. Water temperatures exceed criteria in the Calapooia River and some tributaries, particularly in the lower subbasin. In general, water temperatures are lower in the forested upper subbasin than in the lower subbasin (Runyon et al., 2004). Elevated water temperatures decrease survival and/or growth of juvenile Chinook, as well as increase prespawning mortality of adult Chinook.

Long-term monitoring of bacteria in the Calapooia River at the Queen Avenue Bridge (in Albany downstream of Oak Creek) by the Oregon Department of Environmental Quality has indicated chronic high levels of *E. coli* (Runyon, et al. 2004).

- *Physical habitat quality.* Modifications to key habitats and the natural processes that form and maintain them have affected all life stages of fish. Impaired physical habitat particularly reduces rearing potential for Chinook and steelhead winter parr. Loss of holding pools causes increased prespawning mortality of adult Chinook. Habitat quality has declined

through changes in interactions between stream systems and their floodplain that have reduced the delivery and transport of large wood, modified gravel deposition, reduced the frequency and depth of pools, minimized hiding cover for adult and juvenile fish, and reduced available spawning areas. Flow modifications and channel confinement and in-stream barriers have reduced access to off-channel habitats essential for juvenile rearing and winter refuge and decreased connectivity between habitats throughout the watershed and the dynamic processes needed to form and maintain habitat diversity (WRI 2004).

- **Habitat access.** Fish passage barriers are an issue throughout the subbasin. There are several dams and diversions that limit upstream migration. The dams and diversions within the Thompson's Mill complex (RM 19.5 to 28.5) have the greatest impact on fish passage. While Sodom Dam is equipped with a fish ladder, migrating spring Chinook are delayed at the base of the dam, which subjects them to additional stress and possible harassment and poaching (Runyon, et al. 2004). Brownsville Dam (RM 36) is equipped with a fish passage ladder but its effectiveness is limited, particularly during high flow periods when spring Chinook, winter steelhead, and cutthroat trout are moving through the river (WRI 2004). In addition, there are numerous unscreened small diversions within the subbasin (WRI 2004).

Table 6-16. Key and Secondary Limiting Factors and Threats to Recovery of Calapooia Spring Chinook and Winter Steelhead.

Threats	Species	Tributaries (Streams and Rivers within Population Area)										West Side Tributaries	Mainstem Willamette (above falls)	Estuary (below Bonneville and Willamette Falls)			Ocean
		Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Kelt	Presmolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult
Harvest	Chinook																
	Steelhead																
Hatchery	Chinook								3						4a		
	Steelhead														4a		
Hydropower/ Flood Control	Chinook												10d	5a,5b,7h,10f 9j			
	Steelhead												10c 10d	5a,5b,7h,10f 9j			
Landuse	Chinook	7a	8a	9a	8a			8b			8a	8a	8a	5a	6e,8a,9a,9h,9i		
				8a				9c									
				10b				2h									
	Steelhead	7a		9a 10b	8a			2h				8a			5a 6e,8a,9a,9h,9i		
Introduced Species	Chinook																
	Steelhead																

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors

- 2h Impaired access to habitat above Calapooia dams.
- 3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- 5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
- 5b Increased microdetrital inputs due to reservoirs.
- 7h Impaired fine sediment recruitment due to dam blockage.
- 8a Impaired physical habitat from past and/or present land use practices.
- 8b Loss of holding pools from past and/or present land use practices resulting in increased prespawning mortality.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9c Elevated water temperatures from past and/or present land use practices leading to prespawning mortality.

- 10c Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.
- 10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors

- 2a Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable sized streams.
- 2h Impaired access to habitat above Calapooia dams.
- 4a Competition with hatchery fish of all species.
- 6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
- 7a Fine sediment in spawning gravel from past and/or present land use practices.
- 8a Impaired physical habitat from past and/or present land use practices.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.
- 10b Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

Table 6-17. Effects of Limiting Factors to Recovery of Calapooia Chinook and Steelhead.

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
Hatchery Management			
<i>Population traits - Hatchery fish interbreeding with wild fish (3)</i>	<i>Spring Chinook:</i> spawners, tributaries (1)	Hatchery fish interbreeding with wild fish results in a risk of altered genetic traits.	Abundance, productivity, diversity
<i>Competition- with hatchery fish of all species (4a)</i>	<i>Spring Chinook:</i> parr & smolts, estuary (2); <i>Winter steelhead:</i> smolts, estuary (2)	Mortality of naturally produced juvenile salmonids which must compete with numerous hatchery fish for limited habitat and food in estuary.	Abundance, productivity, diversity
Hydropower/Flood Control Management			
<i>Food web- Reduced macrodetrital inputs (5a)</i>	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearlings, estuary (1)	Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.	Abundance, productivity, diversity
<i>Food web- - Increased microdetrital inputs (5b)</i>	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearlings, estuary (1)	Increased microdetrital inputs due to reservoirs.	Abundance, productivity, diversity
<i>Physical habitat quality- Impaired fine sediment routing (7h)</i>	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearlings, estuary (1)	Impaired fine sediment recruitment due to dam blockage.	Abundance, productivity, diversity
<i>Water quality-Elevated water temperatures (9j)</i>	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (2); <i>Winter steelhead:</i> yearling, estuary (2)	Elevated water temperatures due to mainstem Columbia reservoir heating.	Abundance, productivity, diversity
<i>Hydrograph/water quantity- Reduced flows (10c)</i>	<i>Winter steelhead:</i> smolts, mainstem Willamette (1)	Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.	Abundance, productivity, diversity
<i>Hydrograph/water quantity- Altered hydrology (10d)</i>	<i>Spring Chinook:</i> parr & smolts, mainstem (2); <i>Winter steelhead:</i> parr & smolts, mainstem (2).	Reduced peak flows decrease channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.	Abundance, productivity, diversity
<i>Hydrograph/water quantity- Altered hydrology (10f)</i>	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1); <i>Winter steelhead:</i> yearling estuary (1)	Altered flows due to Columbia River hydropower system result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat and sediment transport.	Abundance, productivity, diversity
Land Management			
<i>Habitat access- above Calapooia dams (2h)</i>	<i>Spring Chinook:</i> returning adults, tributaries (1); <i>Winter steelhead:</i> returning adults, tributaries (2)	Impaired access to habitat above Calapooia dams.	Abundance, productivity, diversity, spatial

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
			structure
<i>Habitat access:</i> Impaired access (2a)	<i>Winter steelhead:</i> fry, parr, smolts & returning adults, tributaries (2)	Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable-sized streams	Abundance, productivity, diversity, spatial structure
<i>Physical habitat quality-</i> Fine sediment in spawning gravel (7a)	<i>Winter steelhead:</i> eggs & alevin, tributaries (2)	Fine sediment in spawning gravel from past and/or present land use practices.	Abundance, productivity,
<i>Physical habitat quality-</i> Reduced complexity and impaired stream and watershed function (8a)	<i>Spring Chinook & Winter steelhead:</i> winter parr, tributaries (1); <i>Spring</i> <i>Chinook:</i> fry & summer parr, tributaries (2), <i>Spring Chinook:</i> pre-smolts, Westside tributaries (2); <i>Spring</i> <i>Chinook & Winter steelhead:</i> parr and smolts, mainstem (2)	Past and present land practices reduce instream habitat complexity and access to off-channel habitat (removal of large wood from the stream channel, altered riparian conditions, channel straightening, revertments, gravel mining, floodplain connectivity).	Abundance, productivity, distribution, diversity
<i>Habitat access-</i> Reduced habitat access and connectivity (8a)	<i>Spring Chinook & Winter steelhead:</i> winter parr, tributaries (1); <i>Spring</i> <i>Chinook:</i> fry & summer parr, tributaries (2), <i>Spring Chinook:</i> pre-smolts, Westside tributaries (2); <i>Spring</i> <i>Chinook & Winter steelhead:</i> parr and smolts, mainstem (2)	Past and present land management practices reduce access to off-channel habitat and floodplain.	Abundance, productivity,
<i>Physical habitat quality-</i> holding pools (8b)	<i>Spring Chinook:</i> returning adults, tributaries (1)	Loss of holding pools from past and/or present land use practices resulting in increased prespawning mortality.	Abundance, productivity,
<i>Water quality –</i> temperature (9a)	<i>Spring Chinook:</i> summer parr, tributaries (1); <i>Winter steelhead:</i> fry and summer parr, tributaries (2)	Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.	Abundance, distribution, diversity, and productivity
<i>Water quality –</i> temperatures (9c)	<i>Spring Chinook:</i> returning adults, tributaries (1)	Elevated water temperatures from past and/or present land use practices leading to prespawning mortality.	Abundance, distribution, diversity, and productivity
<i>Water quality – toxicity</i> (9h, 9i)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (2); <i>Winter steelhead:</i> yearling, estuary (2)	Toxicity due to agricultural, urban and industrial practices.	Abundance, diversity, and productivity
<i>Hydrograph/water</i> <i>quality- water</i> <i>withdrawals (10b)</i>	<i>Spring Chinook:</i> summer parr, tributaries (2); <i>Winter steelhead:</i> fry & summer parr, tributaries (2)	Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.	Abundance, productivity,
<i>Predation- birds (6e)</i>	<i>Spring Chinook:</i> parr & smolts, estuary (2); <i>Winter steelhead:</i> smolts, estuary (2)	Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.	Abundance, diversity, and productivity

6.2.8 Key Limiting Factors and Threats to Recovery for McKenzie River Population of Chinook

This section summarizes limiting factors and threats that are specific to the McKenzie Chinook population. Table 6-18 identifies the key and secondary limiting factors and threats to recovery of McKenzie Chinook. Table 6-19 shows the effects of the limiting factors on different population life stages and VSP parameters, locations where impacts occur, and specific threats. See section 6.2.1 for a discussion of limiting factors and threats (such as Columbia River harvest impacts and effects from the Columbia River hydro system) that are common to Upper Willamette River Chinook populations.

Key threats to the recovery of McKenzie Chinook occur throughout their life cycle and in all spatial areas except the ocean and in West-side tributaries to the Willamette. Harvest was not a key threat at any life stage for the McKenzie Chinook population.

Hatchery Management

Hatchery threats exert key adverse effects on McKenzie Chinook at the adult spawning life stage.

- *Population traits.* Impacts related to this threat category involve the risk of genetic introgression resulting from interbreeding with hatchery Chinook. The spring Chinook hatchery program increases the number of natural spawners below and above Leaburg Dam. In 2001-2004, hatchery fish have comprised 30% to 34% of the natural spawners above Leaburg Dam (Schroeder et al. 2007). Below Leaburg Dam, hatchery fish comprised more than 70% of the natural spawners in 2003 (Firman et al. 2004, cited in NMFS 2004). It is believed the high level of hatchery fish on the spawning grounds in recent years is representative of what occurred over the last few decades. The hatchery program also outplants adults above Cougar and Trail Bridge dams.

Hydropower/Flood Control Management

Threats associated with the Hydropower/flood control category exert key adverse effects on juvenile and adult life stages of McKenzie Chinook within the basin and also affect the fingerling/subyearling and yearling life stages in the estuary. Limiting factors associated with this threat category include:

- *Hydrology/water quantity.* Peak flows have been greatly diminished by Cougar and Blue River dams. Average annual peak flows after the dams were completed in 1968 are only 60 percent of the average annual peak flows that occurred before dam construction. From July to October, average flows are now 13 to 49 percent higher (depending on month) than average flows before dam construction. Conversely, average flows from March to June are 8 to 27 percent lower (depending on month) than flows before dam construction. These changes coincide with reservoir filling in the spring and reservoir releases in summer and fall (Alsea Geospatial, et al. 2000).
- *Physical habitat quality.* Reduced peak flows cause a reduction of channel complexity and diversity of rearing habitat. The dams also capture large wood that historically created

complex habitat conditions. Trail Bridge Dam in the Upper McKenzie River (RM 82) and, to a greater extent, Cougar Dam on the South Fork McKenzie River and Blue River Dam on the Blue River, intercept large wood and sediment from 35 percent of the McKenzie's headwaters (WRI 2004). Together, reductions in the peak flows and reduced delivery of large wood in the channel have also resulted in fewer side channels and other backwater features in the lower river. The mainstem McKenzie below Deerhorn Park (RM 32) has lost most of its islands and side channels (WRI 2004).

- *Habitat access.* Impaired access to habitat above dams. Cougar Dam on the South Fork has resulted in significant loss of access to historically productive spring Chinook habitat. Blue River dam was built without fish passage facilities, but little Chinook spawning habitat was lost because a falls two miles upstream already limited distribution. In addition, EWEB's Trail Bridge Dam blocks access to the uppermost three miles of the mainstem McKenzie River and a portion of Smith River.

Land Management

Present or historical land use practices exert key adverse effects on juvenile McKenzie Chinook in the basin, in the mainstem Willamette, and in the estuary.

- *Physical habitat quality.* Altered habitat diversity (channel confinement, riparian function, wood in the channel, and other attributes) has affected all of the spring Chinook life stages in the geographic areas, with larger impacts in the Blue River watershed, lower McKenzie River, lower subbasin tributaries, and Mohawk watershed (WRI 2004). Impacts have degraded rearing potential for winter parr life stage of juveniles.
- *Habitat access.* Culverts and other obstructions limit access in the Mohawk watershed (WRI 2004).

Table 6-18. Key and Secondary Limiting Factors and Threats to Recovery of McKenzie Spring Chinook.

Threats	Species	Tributaries (Streams and Rivers within Population Area)								West Side Tributaries	Mainstem Willamette (above falls)		Estuary (below Bonneville and Willamette Falls)			Ocean
		Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Presmolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult
Harvest	Chinook															
Hatchery	Chinook				4b				3				4a			
					6c											
					6d											
Hydropower/ Flood Control	Chinook	9g			10d		1b	2d	7e			10d	5a,5b,7h,10f 9j			
Landuse	Chinook			8a	8a 9a	8a				8a		8a	5a 6e,8a,9a,9h,9i			
Introduced Species	Chinook															

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors

- 2d Impaired access to habitat above McKenzie hydropower/flood control dams.
- 3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- 5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
- 5b Increased microdetrital inputs due to reservoirs.
- 7h Impaired fine sediment recruitment due to dam blockage.
- 8a Impaired physical habitat from past and/or present land use practices.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.
- 10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors

- 4a Competition with hatchery fish of all species.
- 4b Competition with naturally produced progeny of hatchery spring Chinook.
- 6c Predation by hatchery summer steelhead smolts.
- 6d Predation by hatchery rainbow.
- 6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
- 7e Lack of gravel recruitment below McKenzie hydropower/flood control dams due to gravel capture in upstream reservoirs.
- 8a Impaired physical habitat from past and/or present land use practices.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9g Elevated water temperatures below McKenzie hydropower/flood control dams resulting in premature hatching and emergence.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

Table 6-19. Effects of Limiting Factors to Recovery of McKenzie Spring Chinook.

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
Hatchery Management			
<i>Population traits -</i> Hatchery fish interbreeding with wild fish (3)	<i>Spring Chinook:</i> spawners, tributaries (1)	Hatchery fish interbreeding with wild fish results in a risk of altered genetic traits..	Abundance, productivity, diversity
<i>Competition-</i> with hatchery fish of all species (4a)	<i>Spring Chinook:</i> parr & smolts, estuary (2)	Mortality of naturally produced juvenile salmonids which must compete with numerous hatchery fish for limited habitat and food in estuary.	Abundance, productivity, diversity
<i>Competition-</i> with progeny of hatchery fish (4b)	<i>Spring Chinook:</i> fry, summer parr, winter parr, tributaries (2)	Competition with naturally produced progeny of hatchery spring Chinook.	Abundance, productivity, diversity
<i>Predation-</i> hatchery steelhead smolts (6c)	<i>Spring Chinook:</i> fry, summer parr, tributaries (2)	Predation by hatchery summer steelhead smolts.	Abundance, productivity, diversity
<i>Predation-</i> hatchery rainbow (6d)	<i>Spring Chinook:</i> fry, summer parr, tributaries (2)	Predation by hatchery rainbow trout.	Abundance, productivity, diversity
Hydropower/Flood Control Management			
<i>Habitat access-</i> above McKenzie hydropower/flood control dams (2d)	<i>Spring Chinook:</i> returning adults, tributaries (1)	Impaired access to habitat above McKenzie hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Food web-</i> Reduced macrodetrital inputs (5a)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1)	Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.	Abundance, productivity, diversity
<i>Food web-</i> Increased microdetrital inputs (5b)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1)	Increased microdetrital inputs due to reservoirs.	Abundance, productivity, diversity
<i>Physical habitat quality-</i> gravel recruitment (7e)	<i>Spring Chinook:</i> spawners, tributaries (2)	Lack of gravel recruitment below McKenzie hydropower/flood control dams due to gravel capture in upstream reservoirs.	Productivity
<i>Physical habitat quality-</i> Impaired fine sediment routing (7h)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (1)	Impaired fine sediment recruitment due to dam blockage.	Abundance, productivity, diversity
<i>Water quality –</i> temperatures (9g)	<i>Spring Chinook:</i> eggs & alevins, tributaries (2)	Elevated water temperatures below McKenzie hydropower/flood control dams resulting in premature hatching and emergence.	Abundance, diversity, and productivity
<i>Water quality-</i> Elevated water temperatures (9j)	<i>Spring Chinook:</i> fingerling, subyearling, yearling, estuary (2)	Elevated water temperatures due to mainstem Columbia reservoir heating.	Abundance, diversity, and productivity

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
<i>Hydrograph/water quantity- Altered hydrology (10d)</i>	<i>Spring Chinook</i> : fry and parr, tributaries, (1) <i>Spring Chinook</i> : parr and smolts, mainstem (2)	Reduced peak flows decrease channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.	Abundance, diversity, and productivity
<i>Hydrograph/water quantity- Altered hydrology (10f)</i>	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (1)	Altered flows due to Columbia River hydropower system result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat and sediment transport.	Abundance, diversity, and productivity
Land Management			
<i>Physical habitat quality- Reduced complexity and impaired stream and watershed function (8a)</i>	<i>Spring Chinook</i> : winter parr, tributaries (1); <i>Spring Chinook</i> : parr and smolts, mainstem (1); <i>Spring Chinook</i> : fry & summer parr, tributaries (2), <i>Spring Chinook</i> : pre-smolts, Westside tributaries (2)	Past and present land practices reduce instream habitat complexity and access to off-channel habitat (removal of large wood from the stream channel, altered riparian conditions, channel straightening, revertsments, gravel mining, floodplain connectivity).	Abundance, productivity, distribution, diversity
<i>Habitat access- Reduced habitat access and connectivity (8a)</i>	<i>Spring Chinook</i> : winter parr, tributaries (1); <i>Spring Chinook</i> : parr and smolts, mainstem (1); <i>Spring Chinook</i> : fry & summer parr, tributaries (2), <i>Spring Chinook</i> : pre-smolts, Westside tributaries (2)	Past and present land management practices reduce access to off-channel habitat and floodplain.	Abundance, productivity, distribution, diversity
<i>Water quality – temperature (9a)</i>	<i>Spring Chinook</i> : summer parr, tributaries (1)	Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.	Abundance, distribution, diversity, and productivity
<i>Water quality – toxicity (9h, 9i)</i>	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (2)	Toxicity due to agricultural, urban and industrial practices.	Abundance, diversity, and productivity
<i>Predation- birds (6e)</i>	<i>Spring Chinook</i> : parr & smolts, estuary (2)	Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.	Abundance, diversity, and productivity

6.2.9 Key Limiting Factors and Threats to Recovery for Middle Fork Willamette Population of Chinook

This section summarizes limiting factors and threats that are specific to Middle Fork Willamette Chinook. Table 6-20 identifies the key and secondary limiting factors and threats to recovery of the population. Table 6-21 shows the effects of the limiting factors on different life stages and VSP parameters. It also identifies the locations where impacts occur and specific threats to the population. See section 6.2.1 for a discussion of limiting factors and threats (such as Columbia River harvest impacts and effects from the Columbia River hydro system) that are common to Upper Willamette River Chinook populations.

Key threats to the recovery of Middle Fork Willamette Chinook occur throughout their life cycle and in all spatial areas except the ocean and in West-side tributaries to the Willamette. Harvest was not a key threat at any life stage for the Middle Fork Willamette Chinook population.

Hatchery Management

Hatchery threats exert key adverse effects on Middle Fork Willamette Chinook at the adult spawning life stage.

- *Population traits.* Releases of hatchery Chinook pose risks of genetic introgression resulting from interbreeding with hatchery Chinook. The hatchery program is increasing the number of spawners below and above Dexter Dam and in Fall Creek, a tributary to the Middle Fork Willamette.

The proportions of spring Chinook with various life history characteristics are different than the historic populations in the Willamette Basin. Most hatchery produced juveniles are released as age-1 smolts in the spring, whereas a more continuous migration of naturally produced smolts through the fall and spring periods was observed in the historic populations (Willis, et al. 1995, cited in NMFS 2004). Hatchery Chinook return at an earlier age than the historic populations. Most of the returns now are age-4 fish instead of age-5 (Willis, et al. 1995, cited in NMFS 2004). It is unknown if younger adults is the result of genetic changes as the result of hatchery operations or fisheries, or simply the result of releasing larger smolts than occurred naturally.

Hydropower/Flood Control Management

Threats associated with the Hydropower/flood control category exert key adverse effects on multiple life stages of Middle Fork Willamette Chinook within the basin and also affect the fingerling/subyearling and yearling life stages in the estuary. Limiting factors associated with this threat category include:

- *Hydrology/water quantity.* Elevated flows below the dam occur during spawning and reduced flows during egg incubation can dewater redds below dams. Winter and spring flow reductions below the dams may also reduce rearing area and the survival of fry. Flow fluctuations occur at rates rapid enough to entrap and strand juvenile anadromous fish (WRI 2004).

- *Water quality.* Reduced flows below the dams during spring result in increased water temperatures in the mainstem Willamette and increased potential for disease. Compared to historical conditions, water temperatures in the Middle Fork Willamette below the dam are cooler in the spring and summer and warmer in the fall and winter. Elevated water temperatures below the dams in the fall cause premature hatching of eggs and emergence of fry.
- *Habitat access.* Mortality of juvenile Chinook caused by downstream passage through turbines or becoming trapped in the reservoirs because they are unable to locate downstream passage at dams. Prespawning mortality is caused by crowding and high water temperatures below the dams.
- *Habitat access.* Dexter, Lookout Point and Hills Creek dams were built without fish passage facilities and limit access to an estimated 80% of the historical production area for spring Chinook (USACE 2001, cited in WRI 2004). Adult Chinook are trapped at Dexter Dam and trucked to the upper subbasin. ODFW began releasing adult spring Chinook above Hills Creek Reservoir in 1993 to increase nutrient inputs and provide a prey base for bull trout (WRI 2004).

Fall Creek Dam is a barrier to fish movement. A trapping facility is in place but upstream migrants could experience abrasion, mechanical injury, and stress, and experience delay in migration and disease when water temperatures are above maximum (WRI 2004).

- *Physical habitat quality.* Dexter, Lookout Point, Hills Creek and Fall Creek dams have altered the links between the upper and lower subbasin, thus reducing the transport and delivery of large wood and substrate to downstream reaches. Because the dams capture material, delivery of large wood to the lower Middle Fork Willamette River is blocked from 90% of the subbasin (USACE 2001, cited in WRI 2004). In addition, the frequency of large magnitude flows is not of sufficient to create and maintain channel complexity and provide nutrients, organic matter, and sediment inputs from floodplain areas (WRI 2004). Changes in the abundance and distribution of gravels, small cobbles, and large wood (particularly in large jams) have reduced suitable spawning areas and limited areas for adult cutthroat trout and juvenile rearing habitat for spring Chinook.

Land Management

Present or historical land use practices exert key adverse effects on Middle Fork Willamette Chinook juveniles in the basin, in the mainstem Willamette, and in the estuary.

- *Habitat access.* Numerous partial and complete fish passage barriers at culverts may limit juvenile upstream movement into refuge habitat (WRI 2004)
- *Physical habitat quality.* Revetments line 50% of the lower eight miles of the Middle Fork Willamette, which limits habitat complexity. Lower river reaches have lost sinuosity, side-channel length, alcoves, and gravel bars.

The lower subbasin contains only a small fraction of the original floodplain forest. Remaining floodplain forests are interspersed with areas of farmland, pastureland, highways, residences and other development. Riparian vegetation within 100 feet of the small tributaries of the lower Middle Fork Willamette is generally in poor condition. Changes in riparian canopy cover have increased summer high water temperatures on some tributary streams (WRI 2004).

- Historical removal of large wood from tributary streams, reduced transport of wood below the dams, and changes in riparian vegetation all have interacted to reduce the quantity and distribution of large wood in the river and tributaries. Limited wood in the river and tributary channels limits the formation of pools, thus reducing hiding areas for adult fish and restricting the quality and quantity of juvenile rearing habitat (WRI 2004).
- Roads next to stream channels have increased channel confinement and reduced riparian vegetation and canopy cover.
- *Water quality.* Maximum temperatures for adult migration have been exceeded in the Middle Fork Willamette and Fall Creek below the dams, the upper Middle Fork Willamette above Hills Creek Reservoir, Salt Creek, the North Fork of the Middle Fork Willamette, Lost Creek, Fall Creek above Fall Creek Dam, and other tributaries.

Table 6-20. Key and Secondary Limiting Factors and Threats to Recovery of Middle Fork Willamette Spring Chinook.

Threats	Species	Tributaries (Streams and Rivers within Population Area)								West Side Tributaries	Mainstem Willamette (above falls)		Estuary (below Bonneville and Willamette Falls)			Ocean
		Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Presmolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult
Harvest	Chinook															
Hatchery	Chinook								3				4a			
Hydropower/ Flood Control	Chinook	9f			10d		1f	2e	7f			10d	5a,5b,7h,10f			
		7g						2m					9j			
Landuse	Chinook			8a	8a	8a				8a		8a	5a			
					9a								6e,8a,9a,9h,9i			
Introduced Species	Chinook															

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors

- 1f Mortality at Middle Fork Willamette hydropower/flood control dams. This mortality is due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
- 2e Impaired access to habitat above Middle Fork Willamette hydropower/flood control dams.
- 2m Pre-spawning mortality due to crowding and high water temperatures below Middle Fork Willamette hydropower/flood control dams.
- 3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- 5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
- 5b Increased microdetrital inputs due to reservoirs.
- 7f Lack of gravel recruitment below Middle Fork Willamette hydropower/flood control dams due to gravel capture in upstream reservoirs.
- 7h Impaired fine sediment recruitment due to dam blockage.
- 8a Impaired physical habitat from past and/or present land use practices (tributaries).
- 9f Elevated water temperatures below Middle Fork Willamette hydropower/flood control dams resulting in premature hatching and emergence.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.
- 10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors

- 4a Competition with hatchery fish of all species.
- 6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
- 7g Streambed coarsening below Middle Fork Willamette hydropower/flood control dams due to reduced peak flows.
- 8a Impaired physical habitat from past and/or present land use practices (presmolts, Westside tributaries).
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.

- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

Table 6-21. Effects of Limiting Factors to Recovery of Middle Fork Willamette Chinook.

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
Hatchery Management			
<i>Population traits - Hatchery fish interbreeding with wild fish (3)</i>	<i>Spring Chinook: spawners, tributaries (1)</i>	Hatchery fish interbreeding with wild fish results in altered genetic traits.	Abundance, productivity, diversity
<i>Competition- with hatchery fish of all species (4a)</i>	<i>Spring Chinook: parr & smolts, estuary (2)</i>	Mortality of naturally produced juvenile salmonids which must compete with numerous hatchery fish for limited habitat and food in estuary.	Abundance, productivity, diversity
Hydropower/Flood Control Management			
<i>Habitat access- mortality at dams (1f)</i>	<i>Spring Chinook: smolts, tributaries (1)</i>	Mortality at Middle Fork Willamette hydropower/flood control dams. due to direct mortality in the turbines or smolts being trapped in the reservoirs.	Abundance, productivity, diversity, spatial structure
<i>Habitat access- above Middle Fork Willamette hydropower/flood control dams (2d)</i>	<i>Spring Chinook: returning adults, tributaries (1)</i>	Impaired access to habitat above Middle Fork Willamette hydropower/flood control dams.	Abundance, productivity, diversity, spatial structure
<i>Water quality- pre- spawn mortality (2m)</i>	<i>Spring Chinook: returning adults, tributaries (1)</i>	Prespawning mortality due to crowding and high water temperatures below Middle Fork Willamette hydropower/flood control dams.	Abundance, productivity,
<i>Food web- Reduced macrodetrital inputs (5a)</i>	<i>Spring Chinook: fingerling, subyearling, yearling, estuary (1)</i>	Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.	Abundance, productivity, diversity
<i>Food web- Increased microdetrital inputs (5b)</i>	<i>Spring Chinook: fingerling, subyearling, yearling, estuary (1)</i>	Increased microdetrital inputs due to reservoirs.	Abundance, productivity, diversity
<i>Physical habitat quality- gravel recruitment (7f)</i>	<i>Spring Chinook: spawners, tributaries (2)</i>	Lack of gravel recruitment below Middle Fork Willamette hydropower/flood control dams due to gravel capture in upstream reservoirs.	Productivity
<i>Physical habitat quality- Impaired fine sediment routing (7h)</i>	<i>Spring Chinook: fingerling, subyearling, yearling, estuary (1)</i>	Impaired fine sediment recruitment due to dam blockage.	Abundance, productivity, diversity
<i>Water quality – temperatures (9f)</i>	<i>Spring Chinook: eggs & alevins, tributaries (1)</i>	Elevated water temperatures below Middle Fork Willamette hydropower/flood control dams resulting in premature hatching and	Abundance, diversity, and productivity

Limiting Factor (corresponding chart code)	Species, Primary life stages, Location, Priority ranking: key concern (1), secondary concern (2)	Specific Threat	VSP Parameters Affected
		emergence.	
<i>Water quality</i> -Elevated water temperatures (9j)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (2)	Elevated water temperatures due to mainstem Columbia reservoir heating.	Abundance, diversity, and productivity
<i>Hydrograph/water quantity</i> - Altered hydrology (10d)	<i>Spring Chinook</i> : fry and parr, tributaries, (1); <i>Spring Chinook</i> : parr and smolts, mainstem (2)	Reduced peak flows decrease channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.	Abundance, diversity, and productivity
<i>Hydrograph/water quantity</i> - Altered hydrology (10f)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (1)	Altered flows due to Columbia River hydropower system result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat and sediment transport.	Abundance, diversity, and productivity
Land Management			
<i>Physical habitat quality</i> - Reduced complexity and impaired stream and watershed function (8a)	<i>Spring Chinook</i> : winter parr, tributaries (1); <i>Spring Chinook</i> : parr and smolts, mainstem (1); <i>Spring Chinook</i> : fry & summer parr, tributaries (2), <i>Spring Chinook</i> : pre-smolts, Westside tributaries (2)	Past and present land practices reduce instream habitat complexity and access to off-channel habitat (removal of large wood from the stream channel, altered riparian conditions, channel straightening, revertments, gravel mining, floodplain connectivity).	Abundance, productivity, distribution, diversity
<i>Habitat access</i> - Reduced habitat access and connectivity (8a)	<i>Spring Chinook</i> : winter parr, tributaries (1); <i>Spring Chinook</i> : parr and smolts, mainstem (1); <i>Spring Chinook</i> : fry & summer parr, tributaries (2), <i>Spring Chinook</i> : pre-smolts, Westside tributaries (2)	Past and present land management practices reduce access to off-channel habitat and floodplain.	Abundance, productivity, distribution, diversity
<i>Water quality</i> – temperature (9a)	<i>Spring Chinook</i> : summer parr, tributaries (2)	Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.	Abundance, distribution, diversity, and productivity
<i>Water quality</i> – toxicity (9h, 9i)	<i>Spring Chinook</i> : fingerling, subyearling, yearling, estuary (2)	Toxicity due to agricultural, urban and industrial practices.	Abundance, diversity, and productivity
<i>Predation</i> - birds (6e)	<i>Spring Chinook</i> : parr & smolts, estuary (2)	Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.	Abundance, diversity, and productivity

6.3 Team Composition and Review Materials

Members of the Upper Willamette River Expert Panel and Planning Team played a major role in identifying and rating the main limiting factors and threats to Upper Willamette River Chinook and steelhead populations. These participants are identified in section 6.3.1. Section 6.3.2 provides a web link to source documents made available to team members.

6.3.1 Composition of the Upper Willamette Planning Team

The following individuals were regularly invited to attend Planning Team meetings and comment on Planning Team draft documents and any comments provided by the Upper Willamette Stakeholder Team.

Todd Alsbury – ODFW	Gary Fish – DLCD
Sheila Ault – ODA	Mindy Simmons – USACE
Stephanie Burchfield – NOAA	Steve Mamoyac – ODFW
Mark Chilcote – ODFW	Bruce McIntosh – ODFW
Patty Dornbusch – NOAA	Nikke Moore – BLM
Tim Downey – EWEB	Jo Morgan – ODF
Jill Elliot – Polk County SWCD	Anne Mullan – NOAA
James Ewing – ODF	Tom Murtagh – ODFW
Douglass Fitting -- OWEB	Nicole Navas – DSL
Nancy Gramlich – ODEQ	Jay Nicholas – ODFW
Evan Haas – NOAA	Dave Primozech – Willamette Partnership
Jackie Hastings – Polk County SWCD	Bob Ruediger – BLM
Wayne Hunt – ODFW	Kirk Schroeder – ODFW
Liz Klicker – WRD	Wade Sims – USFS
Sue Knapp – GNRO	Greg Taylor – USACE
Lisa Krentz – ODFW	Mark Wade – ODFW
Lance Kruzic – NOAA	Jeff Weber – DLCD
Gary Lynch – DOGAMI	Deborah Virgovic – USDA NRCS
Jo Morgan – ODF	Chuck Willis – USACE
Manny Farinas – ODFW	Jeff Ziller – ODFW

6.3.2 Source Documents Available to Planning Team

Planning Team members, Expert Panel members, Upper Willamette Stakeholder Team members, and the public have been provided access to a broad range of source materials and documents; these are posted at <http://www.dfw.state.or.us/fish/esa/upper-willamette/index.asp>.

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