Volume II, Chapter 15
Washougal River Subbasin

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15.0 Washougal River Subbasin

15.1 Subbasin Description

15.1.1 Topography & Geology

The headwaters of the Washougal River lie primarily in Skamania County. The river flows mostly southwest through Clark County and enters the Columbia River at RM 121, near the town of Camas, Washington. The drainage area is approximately 240 square miles. The subbasin is part of WRIA 28.

The upper mainstem of the Washougal flows through a narrow, deep canyon until it reaches Salmon Falls at RM 14.5. Below this, the river valley widens, with the lower two miles lying within the broad Columbia River floodplain lowlands. Elevations range from 3,200 feet in the headwaters of Bear Creek to nearly sea level at the Columbia. Due to steep and rugged conditions in most of the basin, development is limited to the lower valley within the Columbia River floodplain. Fish passage was historically blocked to most anadromous fish except steelhead at Salmon Falls (RM 14.5) until a fish ladder was built there in the 1950s. Anadromous fish currently reach only as far as Dougan Falls at RM 21, although summer steelhead regularly negotiate the falls and continue further upstream.

Surface geology in the basin is comprised of volcanic material in the headwater areas and sedimentary material in the lower basin. Alluvium ranging from boulders to sand was deposited in areas north and east of Washougal during repeated catastrophic flooding of the Columbia River during late Pleistocene ice ages. The coarsest sediments were deposited close to the Columbia and finer sediments were deposited further inland. The sand and silt make up of the lower basin is Columbia River floodplain alluvium deposited in more recent times.

15.1.2 Climate

The climate is typified by cool, wet winters and warm, dry summers. Temperatures are moderated by mild, moist air flowing up the Columbia from the Pacific. Precipitation levels are high due to orographic effects. Mean annual precipitation is 85 inches at the Skamania Hatchery (WRCC 2003). Winter temperatures seldom fall below freezing, resulting in low and transient volumes of snowfall.

15.1.3 Land Use/Land Cover

Most of the basin is forested and managed for timber production. Of the basin's land area, 61% is privately owned and most of the remainder is State Forest land. A small portion of the upper basin lies within the Gifford Pinchot National Forest, comprising approximately 8% of the total basin area. Not including the Lacamas Creek basin, most of the private land is owned by private commercial timber companies, except for agricultural land in the lower river valleys, scattered rural residential development, and the urban areas in and around the towns of Washougal and Camas. The Lacamas Creek drainage is made up largely of private land in rural residential or agricultural uses, with the westernmost portion of the basin within the expanding Vancouver metropolitan area. The year 2000 population of the Lacamas Creek basin of 23,800 persons is expected to increase by 35,000 persons by 2020. The population of the remainder of the Washougal subbasin is expected to increase from 12,800 to 34,000 persons (LCFRB 2001). These substantial population increases reflect the eastward expansion of the Vancouver metropolitan area and may serve to increase impacts on watershed processes.

Past timber harvest and large fires (e.g. Yacolt Burn, 1902) have had lasting impacts to the forest vegetation across much of the basin. Residential development has increased dramatically in the Lacamas Creek basin and along the lower 20 miles of the Washougal and in the Little Washougal watershed. Commercial and industrial development dominates the lower basin within the Columbia River floodplain. Land use and land cover in the Washougal River subbasin are illustrated by Figure 15-1 and Figure 15-2. Figure 15-3 displays the pattern of landownership for the basin. Figure 15-4 displays the pattern of land cover / land-use.

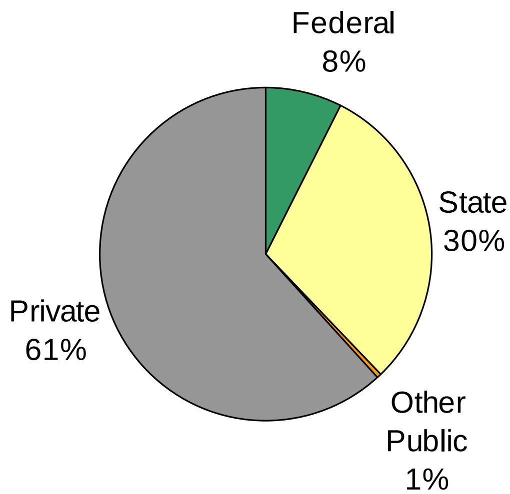


Figure 15-1. Washougal River subbasin land ownership

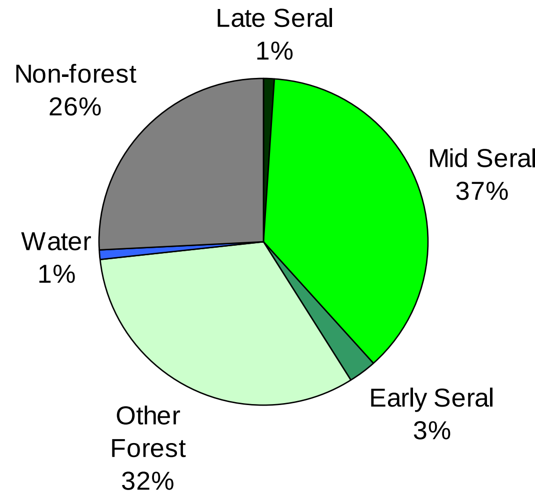


Figure 15-2. Washougal River subbasin land cover

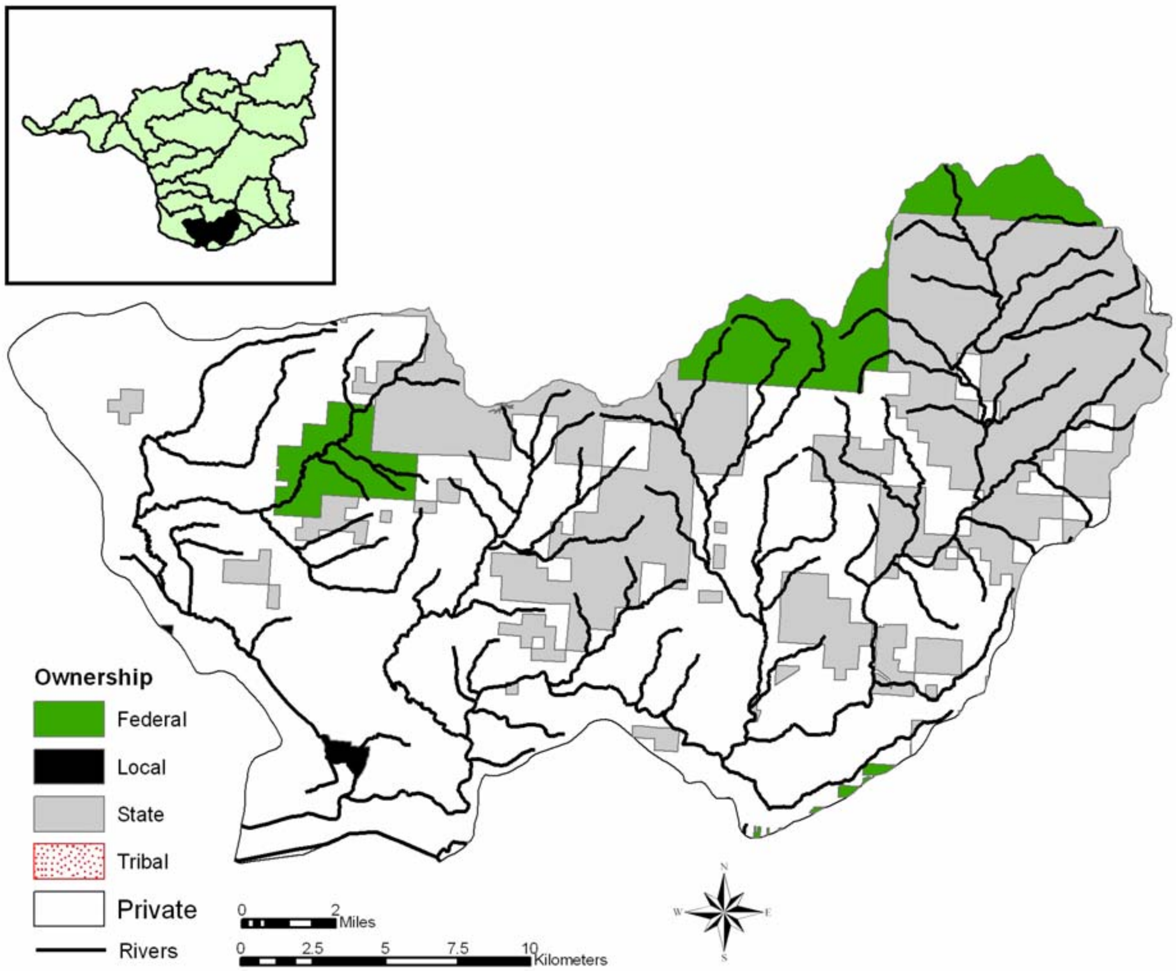


Figure 15-3. Landownership within the Washougal basin. Data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

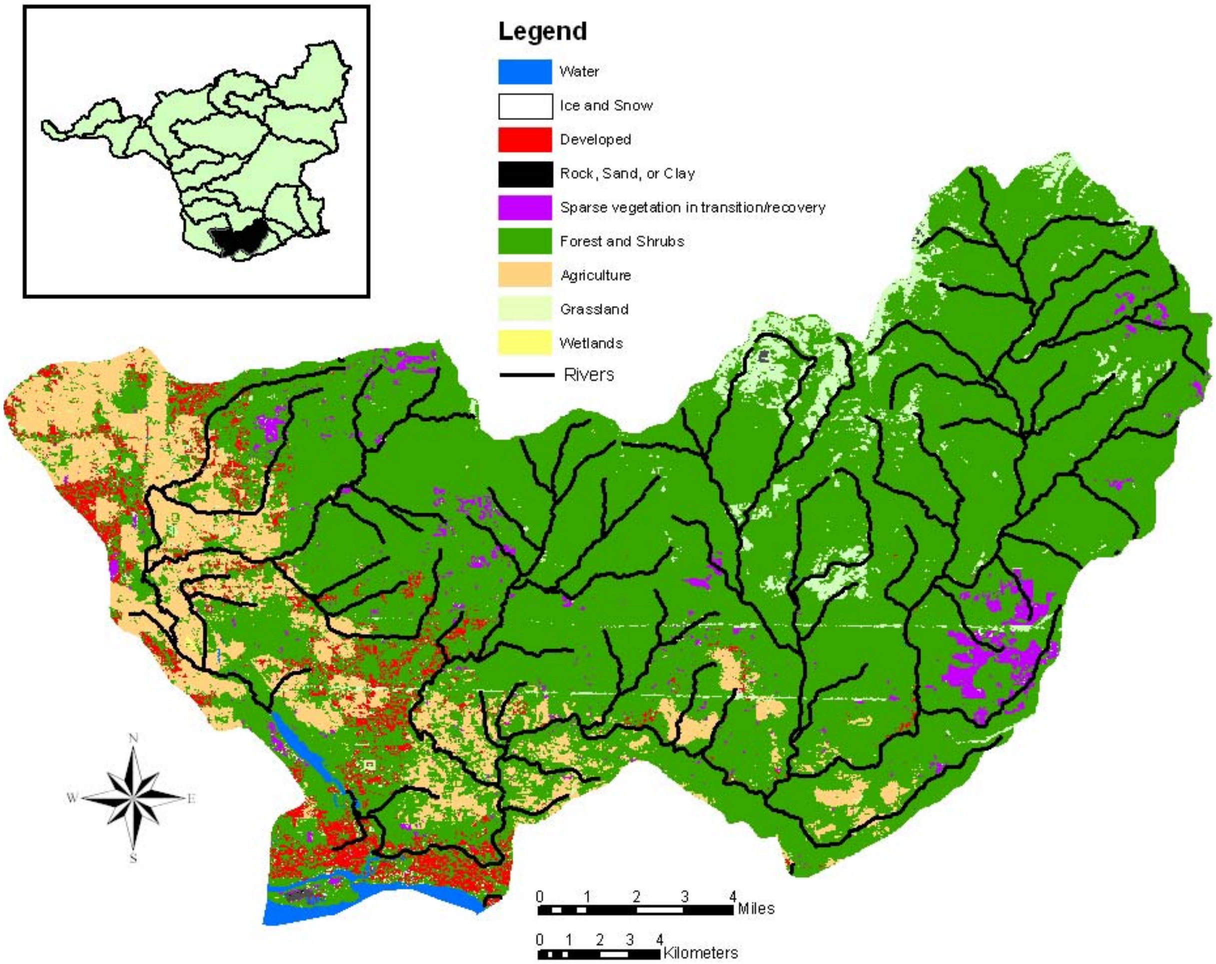
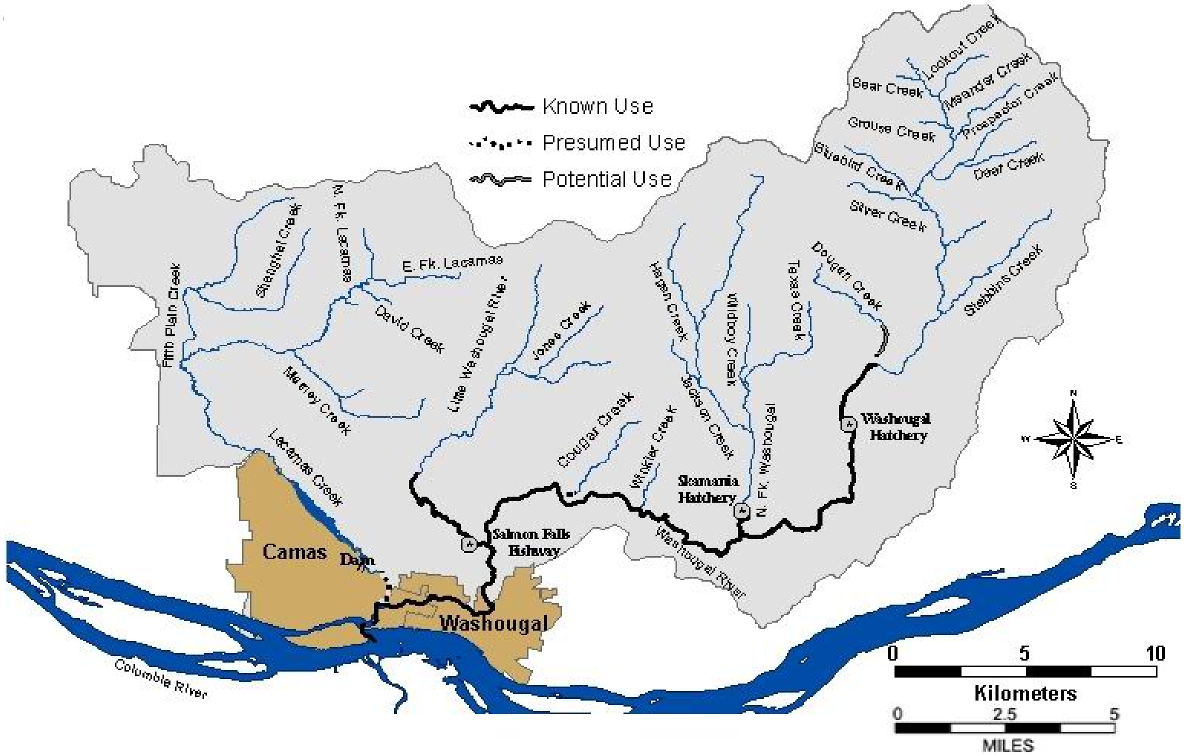


Figure 15-4. Land cover within the Washougal basin. Data was obtained from the USGS National Land Cover Dataset (NLCD).

15.2 Focal Fish Species

15.2.1 Fall Chinook—Washougal Subbasin

ESA: Threatened 1999 **SASSI: Healthy 2002**

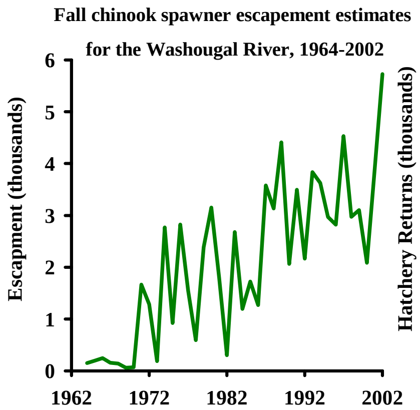


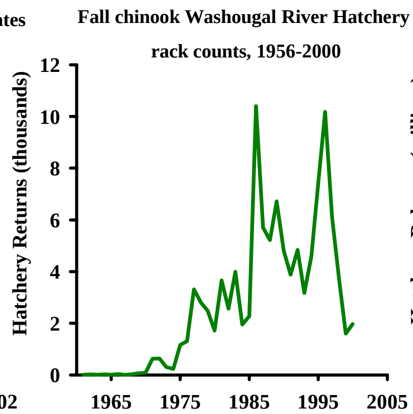
Distribution

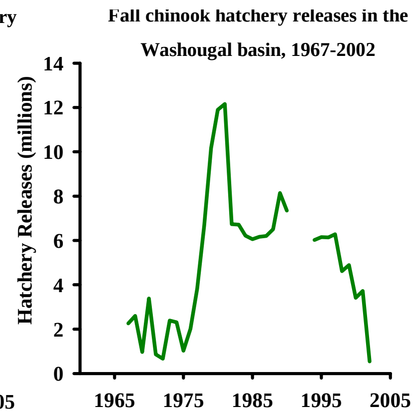
- Natural spawning occurs in the mainstem Washougal primarily between Salmon Falls Bridge (RM 15) and the fish and wildlife access area (~4 miles)
- A ladder was constructed at Salmon Falls in the late 1950s, providing fish access up to Dougan Falls (RM 21.6)
- Annual distribution of natural spawners in the mainstem Washougal is dependent on amount of rainfall from mid-September to mid-October

Life History

- Fall chinook upstream migration in the Washougal River occurs from late September to mid-November, depending on early rainfall
- Spawning in the Washougal River occurs between late September to mid-November
- Age ranges from 2-year old jacks to 6-year old adults, with dominant adult ages of 3 and 4 (averages are 24.8% and 55.2%, respectively)
- Fry emerge in March/April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the summer as sub-yearlings







Diversity

- Considered a tule population in the lower Columbia River Evolutionarily Significant Unit (ESU)
- The Washougal fall chinook stock designated based on distinct spawning distribution
- Genetic analyses of Washougal fall chinook in 1995 and 1996 indicated they are significantly different from other lower Columbia River chinook stocks, except for Lewis River bright fall chinook

Abundance

- WDFW (1951) estimated fall chinook escapement to the Washougal basin was 3,000 fish
- Washougal River spawning escapements from 1964-2001 ranged from 70-4,669 (average 2,000)
- Hatchery production accounts for most fall chinook returning to the Washougal River

Productivity & Persistence

- NMFS Status Assessment for the Washougal River indicated a 0.0 risk of 90% decline in 25 years, 90% decline in 50 years, or extinction in 50 years
- A moderate level of natural production occurs, as illustrated by a WDFW estimate of 5,000,000 natural juvenile fall chinook emigrating from the Washougal basin in 1980
- Hatchery origin spawners that do not convert to the hatchery comprise a significant portion of the natural spawners
- The number of hatchery fish in the natural spawning population is increased in years when rain fall is not sufficient to provide river flows conducive for fish passage to the Washougal Hatchery

Hatchery

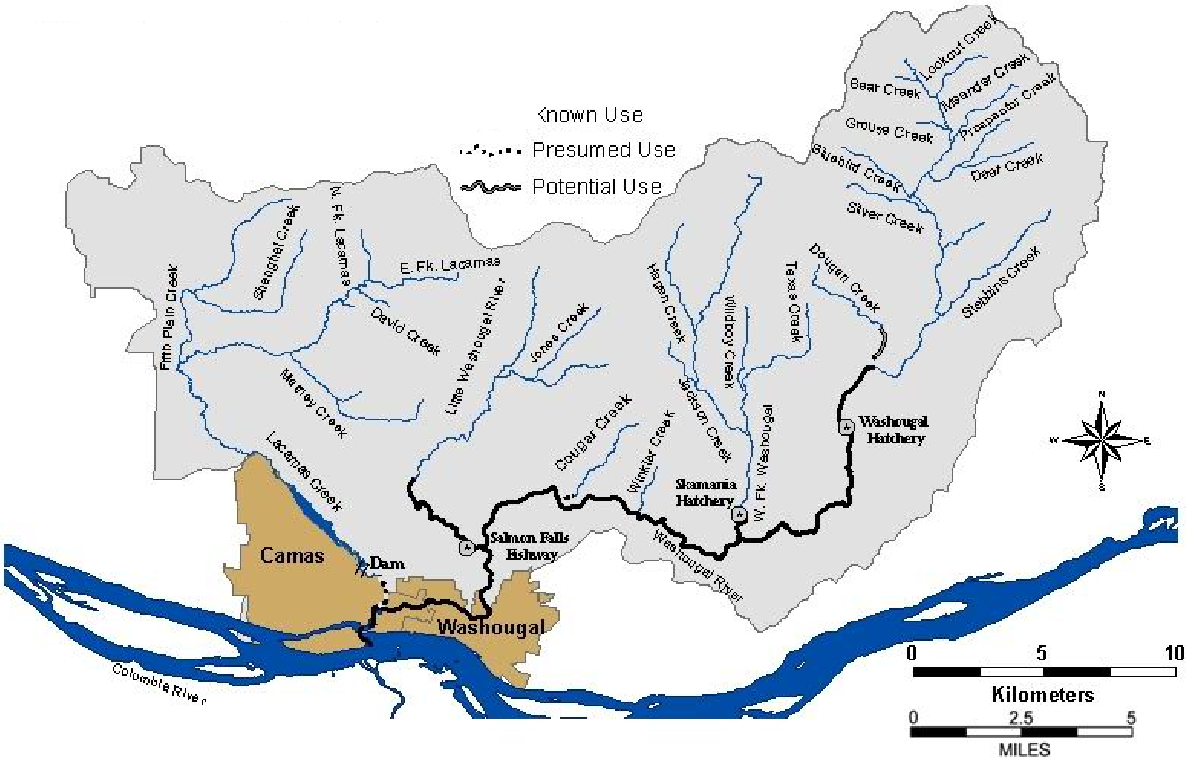
- The Washougal Hatchery (completed in 1958) is located about RM 16.0
- Hatchery releases of fall chinook in the Washougal basin began in the 1950s; numerous lower Columbia broodstock sources were used in the past for Washougal egg take
- Washougal Hatchery returns are generally spawned later than other Columbia River tule stocks; the later time developed over years of selection for the later timed fish because of conditions for passage to the hatchery often delayed until freshets in late October
- The current program releases 3.5 million fall chinook sub-yearlings annually; no outside basin stock have been used in recent years
- Washougal fall chinook releases are displayed for the years 1967-2002

Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- Lower Columbia tule fall chinook are important contributors to the Washington ocean sport and troll fisheries and to the Columbia River estuary sport fishery
- Columbia River commercial harvest occurs primarily in September, but tule chinook flesh quality is low once the fish move from salt water; the price is low compared to higher quality bright stock chinook
- Ocean and mainstem Columbia combined harvest is limited to 49% as a result of ESA limits on Coweemean tule fall chinook
- Current annual harvest rate dependent on management response to annual abundance in PSC (U.S/Canada), PFMC (U.S. ocean), and Columbia River Compact forums
- Coded wire tag (CWT) data analysis of the 1989-1994 brood years indicates a Washougal fall chinook harvest rate of 28% during the mid 1990s
- The majority of 1989-94 brood Washougal fall chinook harvest occurred in Southern British Columbia (35.0%), Alaska (22%), Columbia River (16%), and Washington ocean (14%) fisheries
- Sport harvest in the Washougal River averaged 477 fall chinook annually from 1977-1987

15.2.2 Coho—Washougal Subbasin

ESA: Candidate 1995 **SASSI: Unknown 2002**

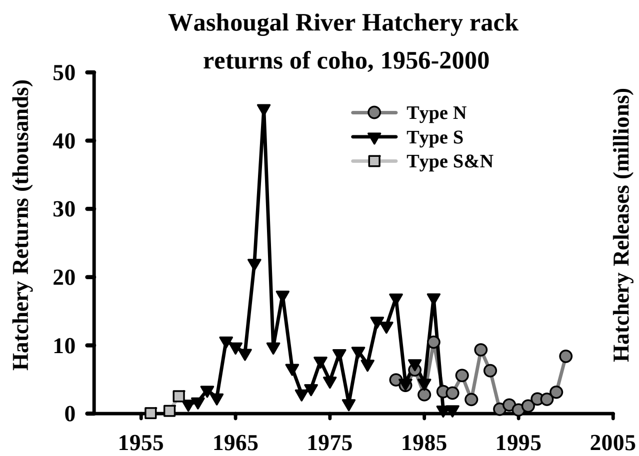


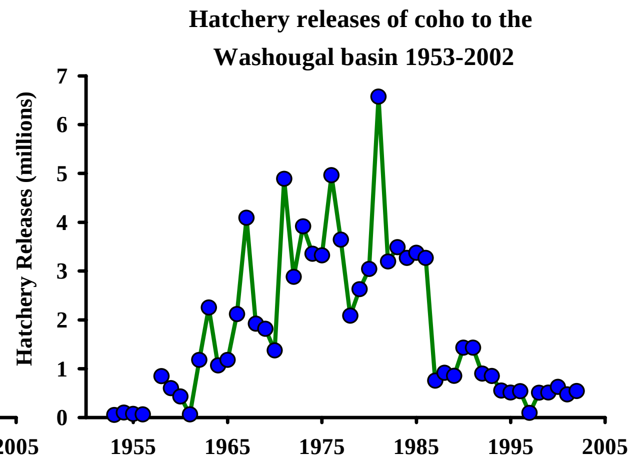
Distribution

- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River
- Managers refer to late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Natural spawning is thought to occur in most areas accessible to coho, but principally in the Little Washougal River with 7.5 miles of stream area habitat
- The West Fork Washougal River and Winkler Creek are also potential production areas
- The mainstem Washougal is not a primary coho spawning area but has some production potential downstream of Salmon Falls (RM 17.5)
- A ladder was constructed at Salmon Falls in the late 1950s, providing fish access up to Dougan Falls (RM 21.6)

Life History

- Adults enter the Washougal River from early September and continue through December
- Peak spawning for early stock occurs in mid-October to November
- Peak spawning for late stock occurs in December and January
- Adults return as 2-year old jacks (age 1.1) or 3-year old adults (age 1.2)
- Fry emerge in late winter/early spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring





Diversity

- Late stock coho (or Type N) were historically produced in the Washougal basin with spawning occurring from late November to March
- Early stock coho (or Type S) were also historically produced in the Washougal basin but in less numbers then the late stock
- Columbia River early and late stock coho produced from Washington hatcheries are genetically similar

Abundance

- Washougal River wild coho run is a fraction of its historical size
- In 1949, it was estimated that the Washougal had spawning area for 6,000 pair of salmon; 5,000 below Salmon Falls and 1,000 between Salmon and Dougan Falls
- In 1951, WDF estimated coho escapement to the basin was 3,000 fish
- Hatchery production accounts for most coho returning to the Washougal River

Productivity & Persistence

- Natural coho production is presumed to be very low
- Coho production limited to lower river tributaries downstream of Dougan Falls
- Natural production of coho has persisted at low levels in the Little Washougal River

Hatchery

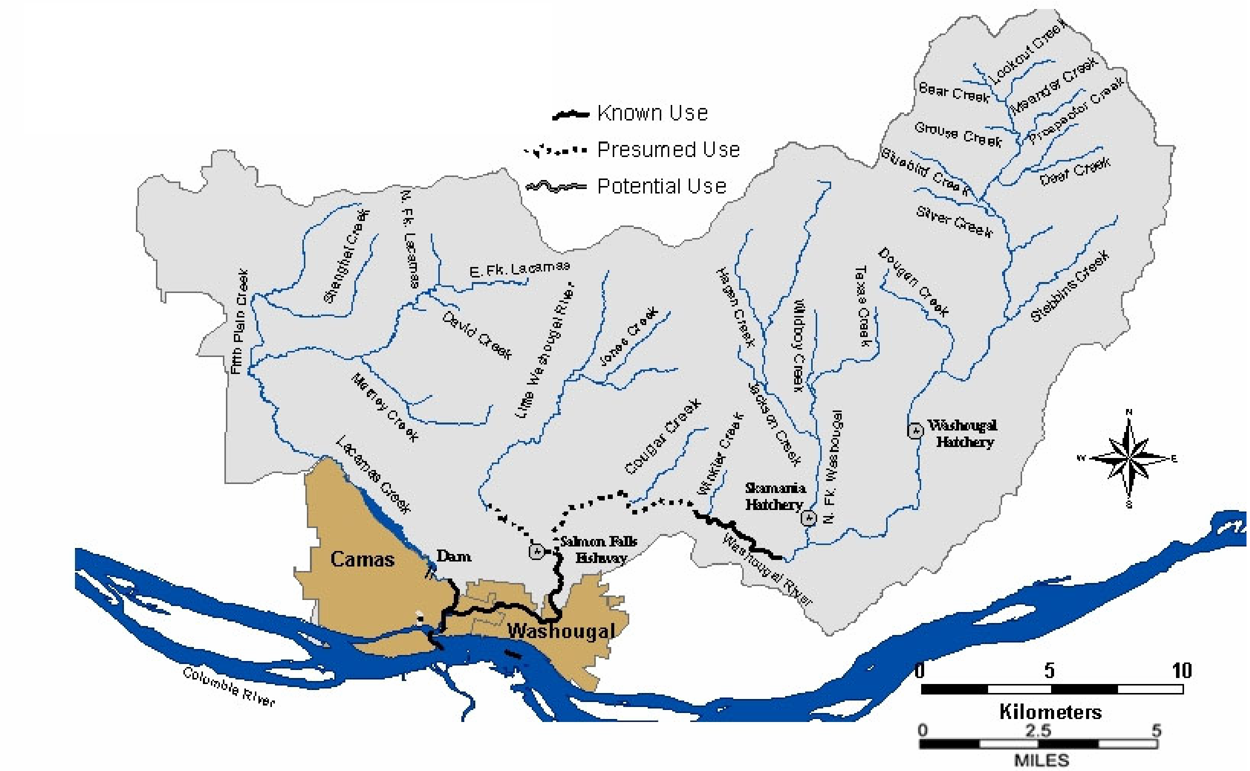
- The Washougal Hatchery (completed in 1958) is located about RM 16.0. Hatchery has produced early and late coho in the past but current program produces only late stock
- Coho have been planted in the Washougal basin since 1958; extensive hatchery coho releases have occurred since 1967
- Current program rears 2.5 million late coho but only releases 0.5 million into the Washougal River; the remaining 2 million are released into the Klickitat River as per a management plan agreement with the Columbia River tribes.

Harvest

- Until recent years, natural produced coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% during 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fishing in November was eliminated in the 1990s to reduce harvest of late Clackamas wild coho
- Since 1999, returning Columbia River hatchery coho have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho in September is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- Naturally-produced lower Columbia river coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late hatchery coho harvest can also be substantial
- An average of 924 coho (1979-1986) were harvested annually in the Washougal River sport fishery
- A special snag fishery for disabled fishermen was present near the hatchery until 1986 to harvest surplus hatchery fish; harvest from 1979-1986 averaged 1,193 coho annually
- CWT data analysis of 1995-97 brood Washougal Hatchery late coho indicates 71% were captured in a fishery and 29% were accounted for in escapement
- Fishery CWT recoveries of Washougal late coho are distributed between Columbia River (57%), Washington ocean (30%), and Oregon ocean (13%) sampling areas

15.2.3 Chum—Washougal Subbasin

ESA: Threatened 1999 **SASSI: NA**



Distribution

- Spawning is believed to occur in the lower reaches of the mainstem Washougal River
- Spawning is believed to occur in the Little Washougal

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are age 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts with little freshwater rearing time

Diversity

- There are no recorded hatchery releases into the Washougal River

Abundance

- In 1951, estimated escapement to the Washougal River was a minimum of 1,000 chum per year
- Spawning ground surveys for other salmonids have resulted in chum observations; in 1998, WDFW found one chum in the Washougal; in 2000, one chum was found in Lacamas Creek (a lower tributary, RM 0.8)

Productivity & Persistence

- Chum salmon natural production is low

Hatchery

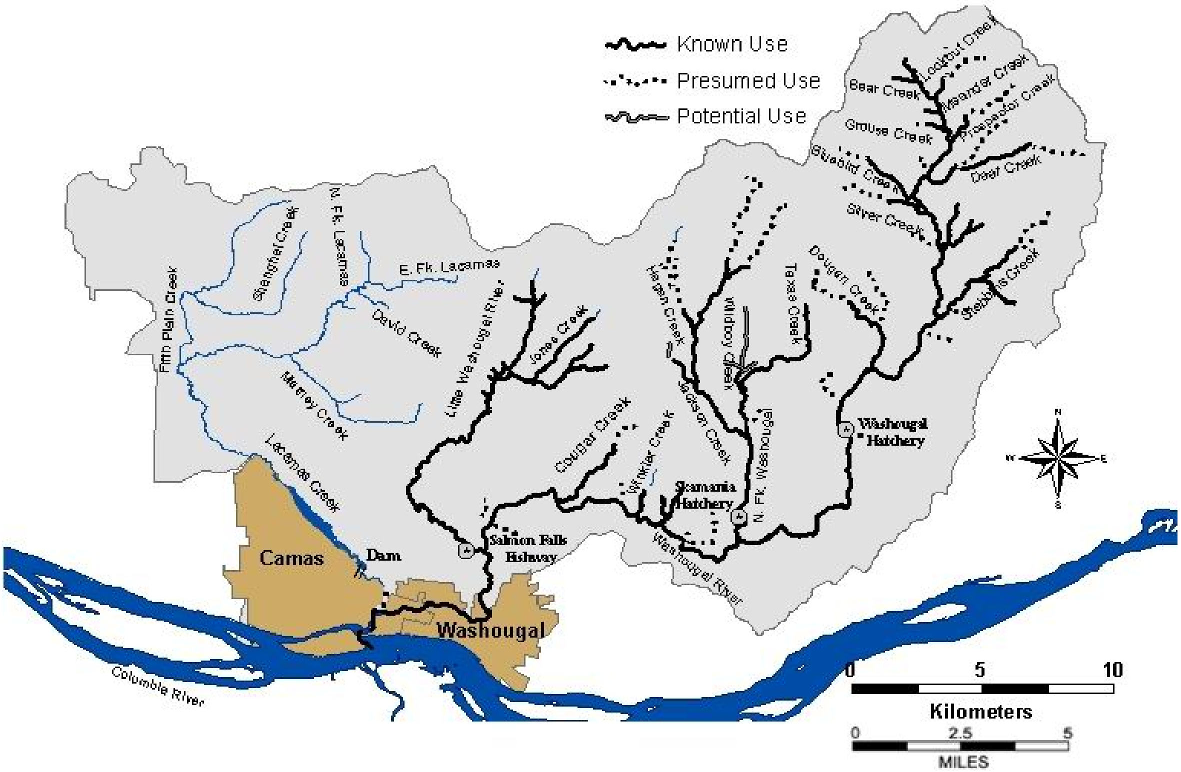
- Chum salmon have not been produced/released in the Washougal River

Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

15.2.4 Summer Steelhead—Washougal Subbasin

ESA: Threatened 1998	SASSI: Unknown 2002

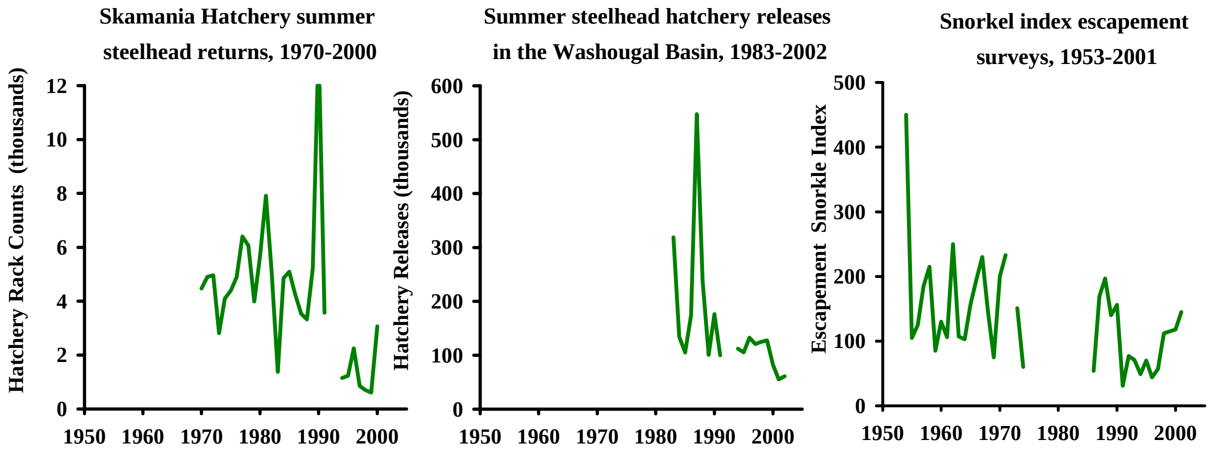


Distribution

- Spawning occurs throughout the mainstem Washougal River, including the tributaries of the West Fork Washougal, the Little Washougal River, and Stebbins and Cougar Creeks
- Several small dams that blocked/impeded steelhead migration have been removed or by-passed, providing access to more of the basin
- Dougan Falls at RM 21 is considered a low water barrier to steelhead; above Dougan Falls, the stream is characterized by a series of falls and cascades

Life History

- Adult migration timing for Washougal summer steelhead is from May through November
- Spawning timing on the Washougal is generally from early March to early June
- The dominant age class is 2.2, although minimal age composition data are available
- Wild steelhead fry emerge from April through July; juveniles generally rear in fresh water for two years; emigration occurs from March to June, with peak migration from mid-April to mid-May



Diversity

- Stock designated based on distinct spawning distribution and early run timing
- Skamania Hatchery summer steelhead broodstock were developed from native Washougal and Klickitat River steelhead
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead may have spawned with native Washougal stocks
- Genetic sampling in 1993 provided little information for determining stock distinctiveness

Abundance

- Between 1925-1933, steelhead run size was estimated at 2,500 fish
- In 1936, 539 steelhead were documented in the Washougal River during escapement surveys
- Snorkel index counts estimated wild steelhead escapement from 1953-2001 ranged from 31 to 500
- Hatchery summer steelhead usually comprise the majority of the spawning escapement; Skamania Hatchery returns have ranged from 1,380 to 13,567 from 1970-1991
- Escapement goal for the Washougal is 1,210 wild adult steelhead

Productivity & Persistence

- NMFS Status Assessment indicated a 0.89 risk of 90% decline in 25 years and a 1.0 risk of 90% decline in 50 years; the risk of extinction in 50 years was not applicable

Hatchery

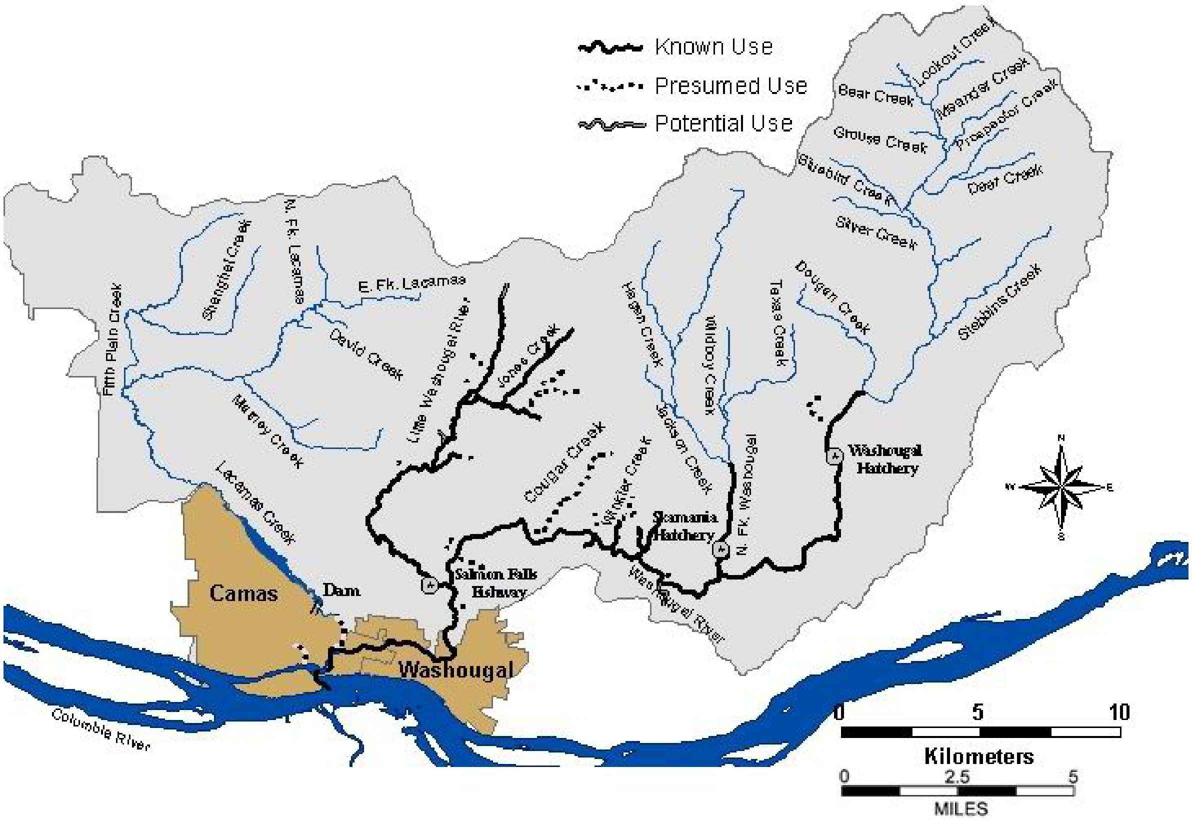
- The Washougal Hatchery (on the mainstem) does not produce summer steelhead
- Skamania Hatchery is located about 1 mile from the mouth of the West Fork; summer steelhead have been released in the basin since the 1950s
- Summer steelhead from the Skamania Hatchery are normally released as smolts directly to the West Fork or mainstem Washougal; release data are displayed from 1983-2002

Harvest

- No directed fisheries target Washougal summer steelhead; incidental mortality can occur during the Columbia River fall commercial and summer sport fisheries
- Summer steelhead sport harvest in the Washougal River from 1964-1990 ranged from 272 to 5,699; average annual sport harvest from 1983-1990 was 1,560 fish; since 1986, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild Washougal summer steelhead in the mainstem Columbia River and in the Washougal River

15.2.5 Winter Steelhead—Washougal Subbasin

ESA: Threatened 1998	SASSI: Depressed 2002

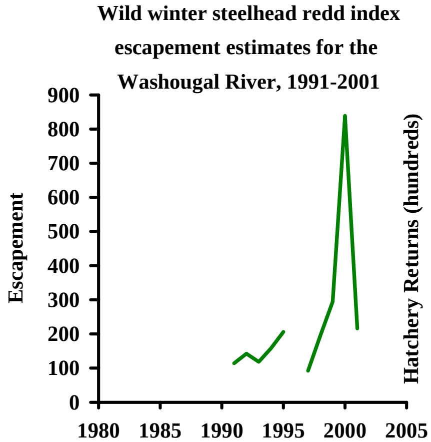


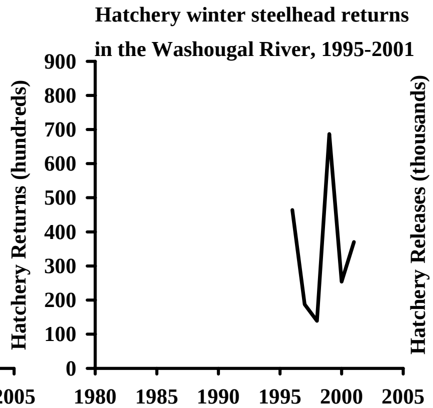
Distribution

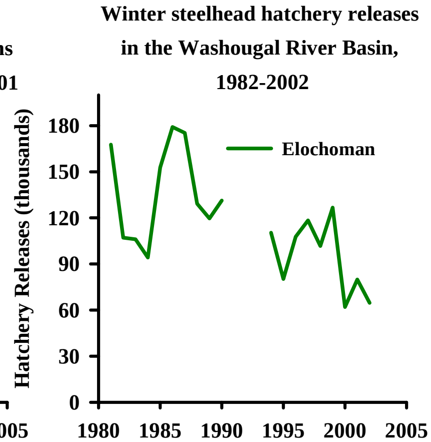
- Spawning occurs throughout the mainstem Washougal River, including the tributaries of the West Fork Washougal, the Little Washougal River, and Stebbins and Cougar Creeks
- Several small dams that blocked/impeded steelhead migration have been removed or by-passed, providing access to more of the basin
- Dougan Falls at RM 21 is considered a low water barrier to steelhead; above Dougan Falls, the stream is characterized by a series of falls and cascades

Life History

- Adult migration timing for Washougal winter steelhead is from December through April
- Spawning timing on the Washougal is generally from early March to early June
- Limited age composition data for Washougal River winter steelhead suggest that most adults are 2-ocean fish
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May







Diversity

- Washougal winter steelhead stock is designated based on distinct spawning distribution and late run timing.
- Wild stock interbreeding with Skamania Hatchery brood stock is thought to be low because of differences in spawn timing.
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead may have spawned with native Washougal stocks.

Abundance

- In 1936, 539 steelhead were documented in the Washougal River during escapement surveys
- Winter steelhead redd index escapement counts for the Washougal River from 1991-2001 ranged from 92 to 839 (average 237)
- Escapement goal for the Washougal River is 841 wild adult steelhead; escapement goal has been met once since 1991
- Hatchery origin fish comprise most of the winter steelhead run on the Washougal

Productivity & Persistence

- Winter steelhead natural production is expected to be low

Hatchery

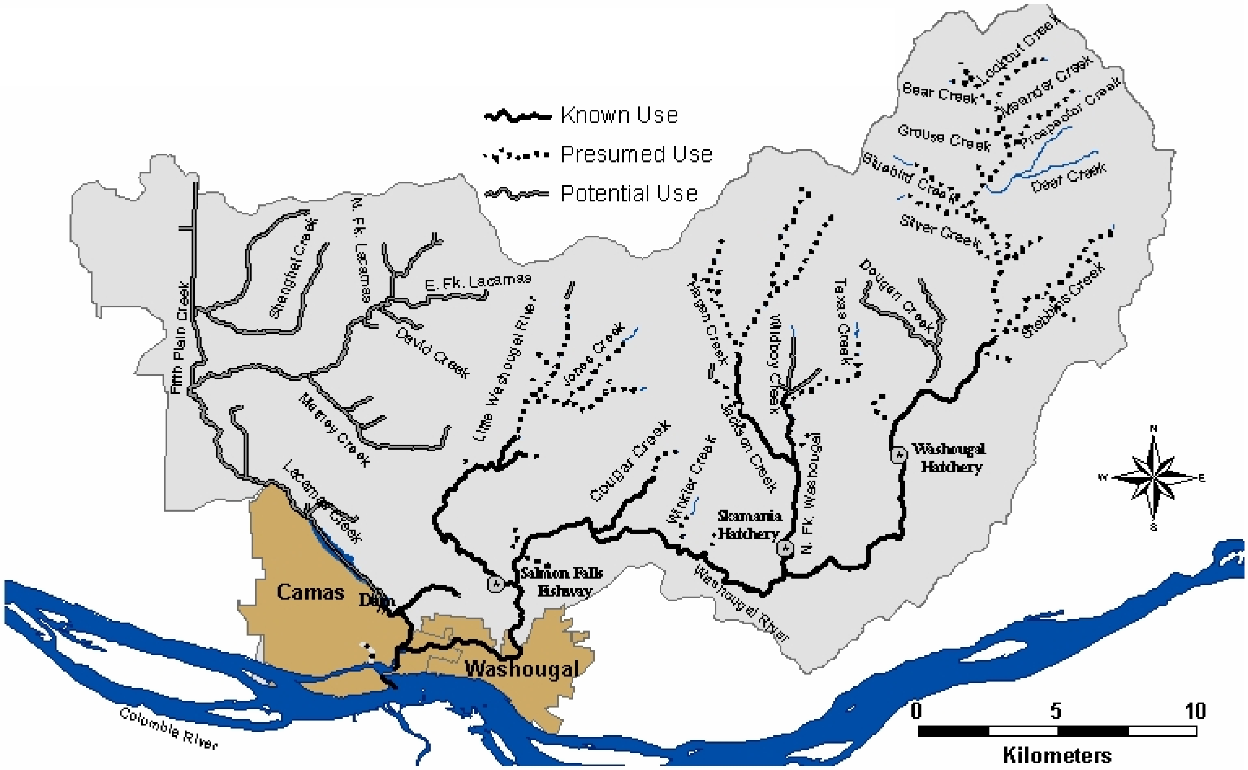
- The Washougal Hatchery (on the mainstem) does not produce winter steelhead
- Skamania Hatchery is located about 1 mile from the mouth of the West Fork; winter steelhead have been released in the basin since the 1950s; production of winter steelhead smolts was approximately 260,000 annually in the early 1990s; current winter steelhead releases are approximately 110,000 smolts annually
- Winter steelhead from the Skamania Hatchery are normally released as smolts directly to the West Fork or mainstem Washougal; release data are available from 1982-2002
- Hatchery fish contribute little to natural winter steelhead production in the Washougal River basin

Harvest

- No directed commercial or tribal fisheries target Washougal winter steelhead; incidental harvest currently occurs during the lower Columbia River spring chinook gillnet fisheries
- Treaty Indian harvest does not occur in the Washougal River basin
- Winter steelhead sport harvest (hatchery and wild) in the Washougal River from 1980-1990 ranged from 1,377 to 3,195 fish; since 1991 and 1992, respectively, regulations limit harvest on the mainstem and West Fork Washougal to hatchery fish only
- ESA limits fishery impact on wild winter steelhead in the mainstem Columbia River and in the Washougal River

15.2.6 Cutthroat Trout—Washougal River Subbasin

ESA: Not Listed	SASSI: Unknown



Distribution

- Anadromous forms are found up to Dougan Falls
- Advfluvial fish exist in Lacamas Lake
- Resident and fluvial forms are documented throughout the system

Life History

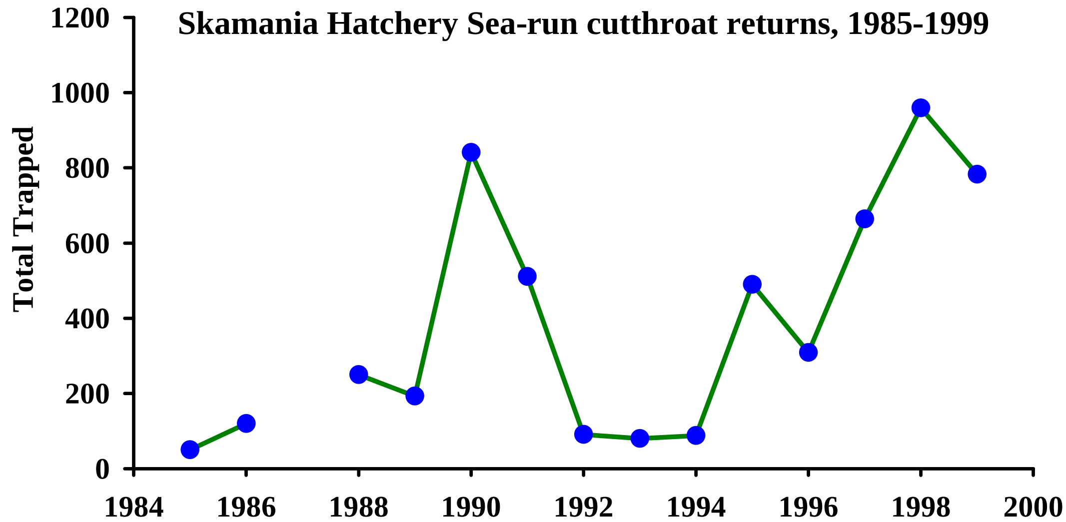
- Anadromous, fluvial, adfluvial and resident forms are present
- Anadromous river entry is from July through December
- Anadromous spawning occurs from December through June
- Resident spawn timing is from February through June

Diversity

- No genetic sampling or analysis has been conducted
- Genetic relationship to other stocks and stock complexes is unknown

Abundance

- Insufficient quantitative data are available to identify wild cutthroat abundance or survival trends
- Adult sea-run cutthroat returns to Skamania Hatchery range from 50-959 fish for the period 1985-1998
- Anecdotal information from local residents suggest that the stock is Depressed



Hatchery

- Washougal and Skamania Hatcheries releases coho, chinook and steelhead into the subbasin each year
- Skamania Hatchery cutthroat trout program was discontinued in 1999

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia summer fisheries downstream of the Washougal River
- Wild Washougal cutthroat (unmarked) must be released in mainstem Columbia River and Washougal River sport fisheries

15.3 Potentially Manageable Impacts

In Volume I of this Technical Foundation, we evaluated factors currently limiting Washington lower Columbia River salmon and steelhead populations based on a simple index of potentially manageable impacts. The index incorporated human-caused increases in fish mortality, changes in habitat capacity, and other natural factors of interest (e.g. predation) that might be managed to affect salmon productivity and numbers. The index was intended to inventory key factors and place them in perspective relative to each other, thereby providing general guidance for technical and policy level recovery decisions. In popular parlance, the factors for salmon declines have come to be known as the 4-H's: hydropower, habitat, harvest, and hatcheries. The index of potentially manageable mortality factors has been presented here to prioritize impacts within each subbasin.

- Loss of tributary habitat quality and quantity is an important impact for all species, particularly for chum and steelhead. Loss of estuary habitat quality and quantity is also important, particularly for chum.
- Harvest has a large relative impact on fall chinook and moderate impacts on coho. Harvest effects on winter and summer steelhead and chum are minimal.
- Hatchery impacts are substantial for coho and winter steelhead, moderate for summer steelhead and fall chinook, and are minimal for chum.
- Predation impacts are moderate for winter and summer steelhead, but appear to be less important for coho, chum, and fall chinook.
- Hydrosystem access and passage impacts appear to be relatively minor for all species.

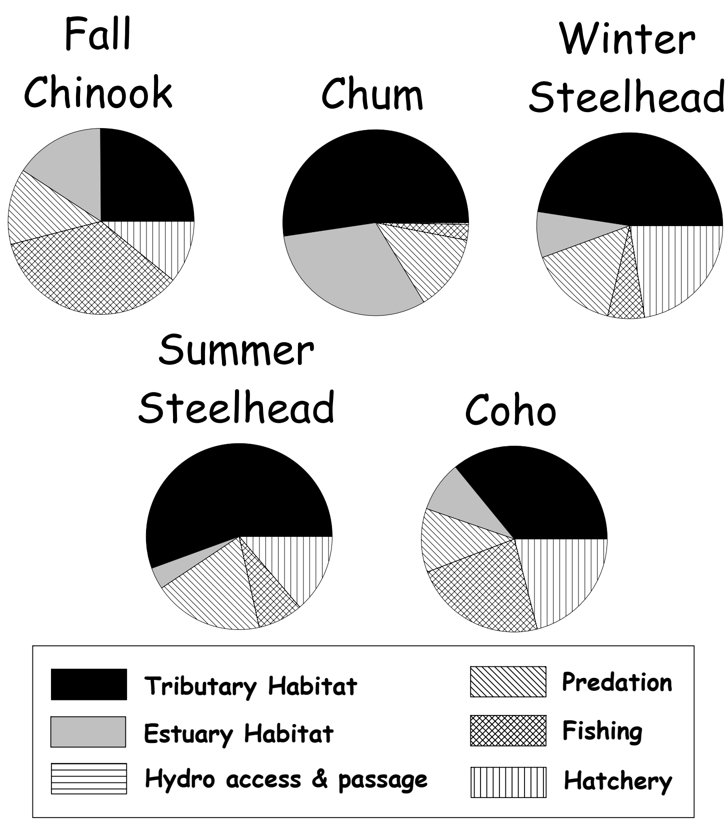


Figure 15-5. Relative contribution of potentially manageable impact factors on listed salmon and steelhead in the Washougal subbasin.

15.4 Hatchery Programs

There are two hatcheries in the Washougal River basin: the Washougal Hatchery and the Skamania Hatchery. The Washougal Hatchery is at about RM 16 of the mainstem and was completed in 1958. It has produced fall chinook, and early (Type-S) and late (Type-N) coho. Current annual releases average 3.5 million sub-yearling fall chinook and 3 million late-run coho smolts, although only 500,000 coho smolts are released in the Washougal basin (Figure 15-6). The remaining 2.5 million coho smolts produced at the Washougal Hatchery are released in the Klickitat River as part of the *US v. Oregon* agreement with the Columbia River treaty Indian Tribes.

The Skamania Hatchery is on the NF Washougal River approximately one mile from the confluence with the mainstem. The hatchery produces 309,000 summer smolts and 190,000 winter steelhead smolts. Steelhead smolts produced at the Skamania Hatchery are released in multiple basins throughout the lower Columbia River; annual release goals for the Washougal River are 60,000 smolts each of summer and winter steelhead (Figure 15-6).

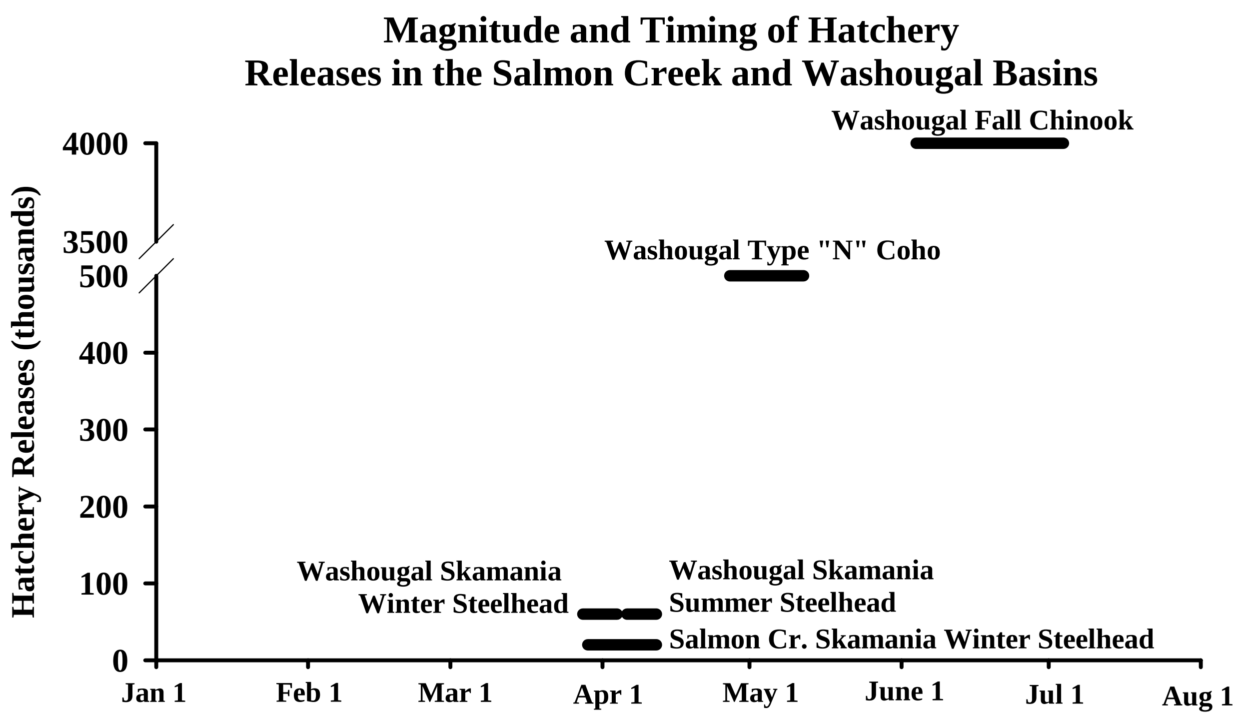


Figure 15-6. Magnitude and timing of hatchery releases in the Salmon Creek and Washougal River basins by species, based on 2003 brood production goals.

Genetics—Broodstock for the Washougal Hatchery fall chinook hatchery program originated from multiple lower Columbia River fall chinook stocks. There have been significant transfers of fall chinook over the years from Spring Creek NFH, Cowlitz Hatchery, Toutle Hatchery, and Kalama Hatchery. Current broodstock collection comes from adults returning to the hatchery. Genetic analysis of Washougal fall chinook in 1995 and 1996 indicated that they were significantly different from other lower Columbia River chinook stocks, except for Lewis River bright fall chinook; this result is perplexing as Washougal fall chinook are considered a tule population.

Broodstock for the Washougal Hatchery coho hatchery program originated from local Washougal early-run coho, with some imported Toutle River early run coho stock used. In 1985, Cowlitz River late-run coho stock was introduced to the Washougal Hatchery broodstock. Since 1987, broodstock has been collected from late-run coho returning to the hatchery, except for 1993 when Lewis River late-run coho were used to supplement the Washougal Hatchery shortfall. Broodstock for the 2.5 million coho smolts released annually to the Klickitat River comes primarily from Lewis River late-run coho stocks. Any lower Columbia River Type-N coho stock has been deemed acceptable broodstock for the Washougal Type-N coho hatchery program.

Broodstock for Skamania Hatchery winter steelhead program originated from local Washougal River winter steelhead; current broodstock comes from adults returning to the hatchery. Shortfalls have been supplemented from Beaver Creek Hatchery winter steelhead stocks, which originated primarily from Chambers Creek and Cowlitz River stocks.

Broodstock for the Skamania Hatchery's summer steelhead program originated from wild fish taken from the Washougal and Klickitat rivers. Current broodstock collection comes from adults returning to the hatchery. Genetic sampling in 1993 was inconclusive in determining the distinctiveness of the Washougal summer steelhead stock. The Skamania summer steelhead stock is the source of nearly all summer steelhead smolt releases on the Washington side of the lower Columbia River, except for the Cowlitz and Lewis rivers.

Interactions—Hatchery production accounts for most adult fall chinook returning to the Washougal River (Figure 15-7). Hatchery-origin fish comprise a significant portion of the natural spawners; this proportion is higher when water flow is low and insufficient to provide for passage to the Washougal Hatchery. A substantial amount of natural production occurs in the system; WDFW estimated 5 million natural juvenile fall chinook emigrated from the Washougal River in 1980 so there may be competition for food and space between naturally produced fall chinook and the average 4 million hatchery fall chinook released annually. Large-scale releases of hatchery fish may attract predators, but the effect on naturally produced salmonids is not clear.

Hatchery production accounts for most adult coho salmon returning to the Washougal River (Figure 15-7); very few wild coho are present, resulting in minimal interaction between adult wild and hatchery coho salmon. Hatchery coho smolts are released volitionally as smolts and clear the river quickly, so competition for food resources with natural salmonids is likely minimal. Some limited natural production of coho has persisted in the Little Washougal River; this tributary is geographically separated from the Washougal Hatchery and any interaction between hatchery fish and naturally produced coho from the Little Washougal would be limited to the lower mainstem. Large-scale releases of hatchery fish may attract predators, but the effect on naturally produced salmonids is not clear.

Hatchery production accounts for most adult winter steelhead returning to the Washougal River (Figure 15-7). Hatchery-origin fish comprise a substantial portion of the natural spawners. However, spawn timing of wild fish and naturally spawning hatchery fish is different; therefore, there is likely minimal interaction between adult wild and hatchery winter steelhead. Hatchery winter steelhead smolts are released volitionally and clear the river quickly, so competition for food resources with natural salmonids is probably minimal. Also, wild steelhead smolt emigration appears to be timed slightly later than the hatchery releases. Only minor residualization of steelhead smolts has been observed on the Washougal River.

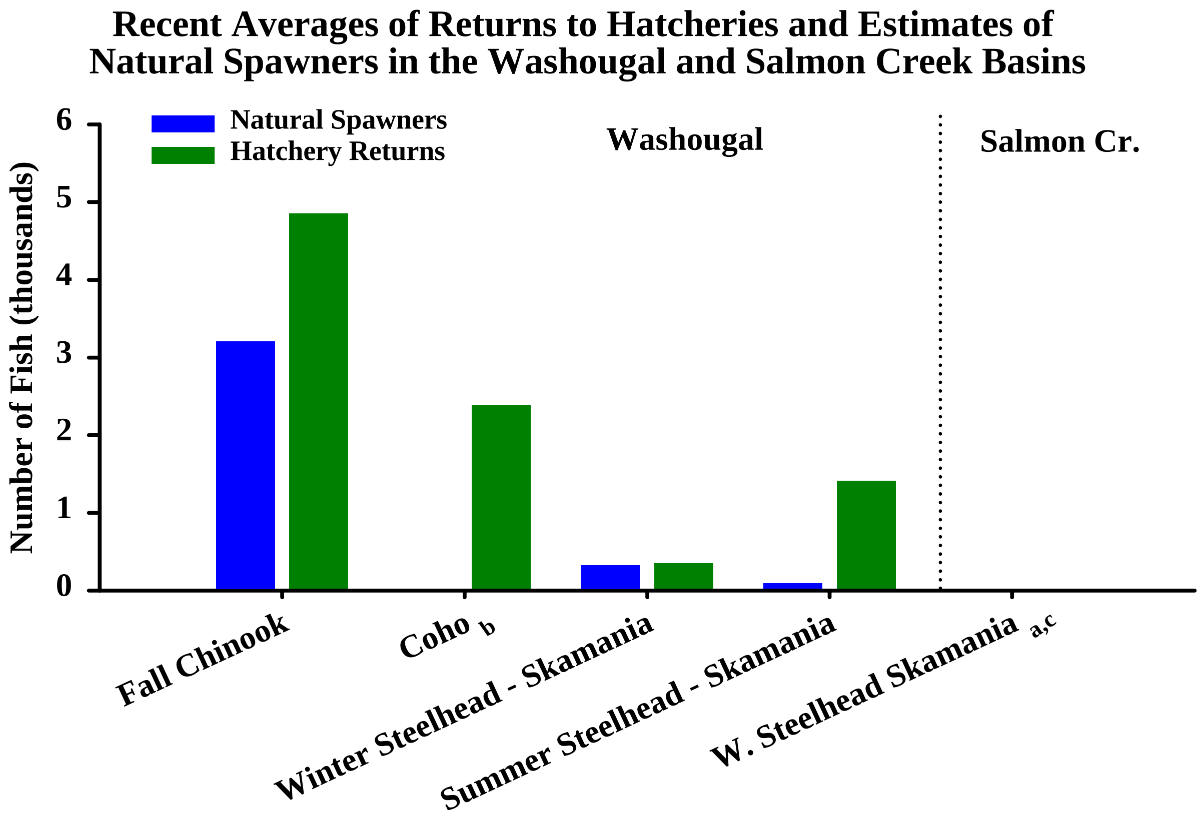


Figure 15-7. Recent average hatchery returns and estimates of natural spawning escapement in the Salmon Creek and Washougal River basins by species.

Hatchery production accounts for most adult summer steelhead returning to the Washougal River, although substantial numbers of wild summer steelhead can be present some years (Figure 15-7). However, because spawn timing of wild fish and naturally spawning hatchery fish is different, little interaction between adult wild and hatchery summer steelhead is thought to occur. Spawn timing between hatchery summer and wild winter steelhead is more similar and there is more potential for interaction between these fish. Hatchery summer steelhead smolts are released volitionally and clear the river quickly, so competition for food resources with natural salmonids is expected to be minimal. Also, wild steelhead smolt emigration appears to be timed slightly later than the hatchery releases. Only minor amounts of residualization of steelhead smolts have been observed on the Washougal River.

Water Quality/Disease—The water source and disease treatment protocol for the Washougal Hatchery were not specified in the available hatchery operational plan. It is assumed that water for the hatchery comes from the Washougal River. Fungus and disease treatment at the Washougal River hatchery is likely similar to other Washington hatcheries; fungus control is presumably achieved with formalin treatments and disease treated with the advice of the area fish health specialist and according to procedures of the Co-Managers Fish Health Policy.

Water for the Skamania Hatchery comes from two sources: the North Fork Washougal River and Vogel Creek. Hatchery water rights total 11,670 gpm but the facility uses an average of 9,800 gpm. Vogel Creek water is used for incubation and early rearing, while Washougal River water is used for all other operations, such as final rearing and adult holding. Hatchery effluent is monitored under the hatchery's NPDES permit. At the adult collection facility, personnel and equipment are sanitized by chlorine disinfection. Fungus in the holding facility is controlled with formalin treatments. During the incubation phase, formalin treatments are used to control ecto-parasites and fungus and eggs and equipment are surface disinfected with iodophor. Fish health is monitored continuously by hatchery staff and the area fish health specialist visits monthly. Disease control is conducted according to the Fish Health Policy. The area fish health specialist inspects fish prior to release and recommends treatment when necessary; control of fish pathogens is done according to the Fish Disease Control Policy. IHN is a major problem in the hatchery and can limit production in some years.

Mixed Harvest—The Washougal River Hatchery provides harvest opportunity to mitigate for fall chinook and coho salmon lost as a result of hydroelectric development in the lower Columbia River basin. Historically, exploitation rates of hatchery and wild fall chinook likely were similar. Fall chinook are an important target species in ocean and Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. CWT data analysis of the 1989–1994 brood years of Washougal fall chinook indicated a 28% exploitation rate on fall chinook; 72% of the adult return was accounted for in escapement. Exploitation of wild fish during the same period likely is similar. Hatchery and wild fall chinook harvest rates remain similar but are now constrained by ESA harvest limitations.

The purpose of the Washougal River Hatchery coho salmon hatchery program is to provide harvest opportunity to mitigate for Columbia River coho salmon lost to hydroelectric development in the basin. The coho program is specifically intended to provide coho for harvest in treaty Indian fisheries in Zone 6 and in the Klickitat River. Historically, naturally produced coho from the Columbia River were managed like hatchery fish and subjected to similar exploitation rates. Ocean and Columbia River combined harvest of Columbia River-produced coho ranged from 70% to over 90% from 1970–83. Ocean fisheries were limited beginning in the mid-1980s and Columbia River commercial fisheries were adjusted in the early 1990s to protect several wild coho stocks. Columbia River coho exploitation rates during 1997 and 1998 averaged 48.8%. CWT data analysis of the 1995–1997 brood years of Washougal River Type-N coho indicated a 71% exploitation rate on late run coho; 29% of the adult return was accounted for in escapement. Most of the Washougal River Type-N coho harvest occurred in the Columbia River. With the advent of selective fisheries for hatchery fish in 1998, exploitation of wild coho is low, while hatchery fish can be harvested at a higher rate. Washougal wild coho benefit from ESA harvest limits for Oregon Coastal natural coho in ocean fisheries and for Oregon lower Columbia Natural Coho in Columbia River fisheries

At the Skamania Hatchery, the summer and winter steelhead hatchery programs provide harvest opportunity to mitigate for summer and winter steelhead lost as a result of hydroelectric development in the lower Columbia River basin. Fisheries that may benefit from these programs include lower Columbia and Washougal River sport fisheries. Prior to selective fishery regulations, exploitation rates of wild and hatchery winter steelhead were likely similar. Mainstem Columbia River sport fisheries became selective for hatchery steelhead in 1984 and the Washougal became selective during 1986–1992. and harvest regulations are aimed at limiting harvest of wild steelhead to fewer than 10%. The sport fishery impact in the Washougal is estimated at 5% for wild winter steelhead and 4% for wild summer steelhead. The hatchery steelhead harvest rate in the Washougal sport fishery is estimated to be 40% for both winter and summer steelhead.

Passage—The adult collection facility at the Washougal Hatchery consists of a weir across the river leading to a ladder and holding pond system. Adults enter the ladder volitionally and are contained in holding ponds until broodstock collection. Adults surplus to annual broodstock needs are distributed throughout the basin for nutrient enhancement of the freshwater rearing environment. In some years, low water flow in the mainstem Washougal River is not conducive to fish passage and broodstock needs are not met.

The adult collection facility at the Skamania Hatchery consists of a ladder, trap, and holding pond system. The ladder is approximately 80 ft long and the trap is approximately 20 ft x 20 ft. Adults enter the ladder volitionally and are routed to one of three holding ponds until broodstock collection. Many fish bypass the hatchery collection facility. Adults surplus to annual broodstock needs may be returned to the river (if in robust condition), planted in landlocked lakes for sport harvest, distributed to food banks, or distributed throughout the basin for nutrient enhancement of the freshwater rearing environment.

Supplementation—No Washougal hatchery program has supplementation as a primary goal. However, hatchery fall chinook and summer steelhead have successfully spawned in the Washougal River; annual natural production varies annually.

15.5 Fish Habitat Conditions

15.5.1 Passage Obstructions

Salmon Falls, at RM 14.5 was the upstream limit of most anadromous fish except steelhead, until a fishway was built in the 1950s to facilitate passage. Currently, Dugan Falls at RM 21 blocks salmon and most winter steelhead, though summer steelhead consistently ascend into the upper reaches. Small dams, weirs, and water diversions restrict access on the mainstem at the Washougal Hatchery, Vogel Creek (water intake for Skamania Hatchery), Jones Creek, Boulder Creek, and Wild Boy Creek. Seven culverts have also been identified that provide partial or complete blockages. A detailed description of passage barriers can be found in the WRIA 28 Limiting Factors Report (Wade 2001).

15.5.2 Stream Flow

The basin is rain-dominated, with little stream flow contributed by snowmelt. Peak flows generally occur in winter months and low flows occur in late summer (Figure 15-8). Flows regularly exceed 1,000 cfs November to April and typically fall below 100 cfs in late summer. The 37-year average discharge is 873 cfs, with a highest-recorded flow of 40,000 cfs in December 1977. The flashy nature of the stream has been attributed to basin topography, denuded vegetation due to large fires, and human alterations to watershed processes (WDF 1990). Major tributaries to the Washougal include Lacamas Creek, the Little Washougal River, Canyon Creek, the West Fork Washougal River, and Dougan Creek.

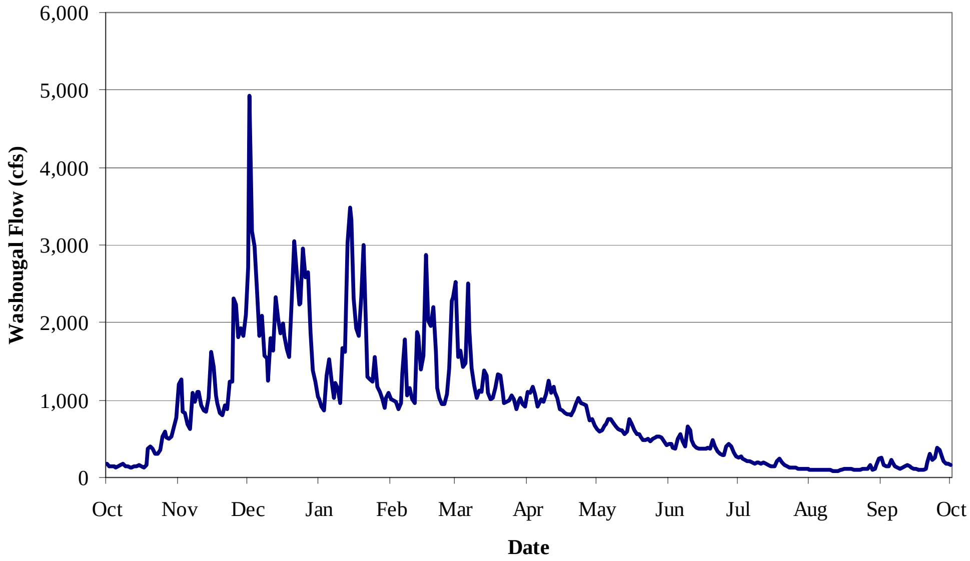


Figure 15-8. Average daily flows for the Washougal River (1972-1981). Peak flows are primarily related to winter and spring rain, with some high peaks occuring due to winter rain-on-snow. Flows fall below 100 cfs in late summer. USGS Stream Gage #14143500; Washougal River near Washougal, Wash.

Vegetation conditions, impervious surfaces, and high road densities in portions of the Washougal basin have potentially impacted runoff regimes. The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, rates 14 of the 29 subwatersheds in the basin as "impaired" with respect to conditions that influence runoff properties. Nine of the subwatersheds are rated as "moderately impaired" and 6 are rated as "functional". The greatest impairments are concentrated in the low elevation subwatersheds and in portions of the upper Lacamas drainage. Intact hydrologic conditions are located primarily in the upper mainstem Washougal headwaters. These results are consistent with an analysis by Lewis County GIS (2000) that identified only the upper Washougal basin as meeting the criteria of a hydrologically functioning watershed.

Instream flow studies have been conducted on several stream segments to assess potential problems with low flows (Caldwell et al. 1999). The IFIM was applied to the Washougal River at approximately RM 3.5. Below optimal flows were identified for chinook and steelhead rearing beginning in July and lasting into October. Other streams were assessed using the Toe-Width method. Data from the Little Washougal River indicated below optimal flows for chinook spawning in the fall and juvenile rearing June through October. Data from the NF Washougal revealed that flows didn't reach optimal for juvenile rearing until October and were below optimal for salmon spawning in the fall. Other areas with low flow concerns include the lower Washougal River, Camas Slough, the Washougal River above Dugan Falls, Texas Creek, Wildboy Creek, Schoolhouse Creek, and Slough Creek (Wade 2001).

In the Lacamas Creek drainage, the current and projected consumptive water use is believed to represent a significant portion of watershed hydrology, although insufficient data exists for a valid comparison of water use and streamflow. For the remainder of the Washougal subbasin, consumptive use appears to represent greater than 10% of base flows and the projected year 2020 water use may approach 25% of summer base flow, assuming full hydraulic connection between ground water and stream flow. There are currenly low-flow restrictions for some surface water rights and the subbasin is near closure for further surface water rights appropriation (LCFRB 2001).

15.5.3 Water Quality

Water quality concerns in the basin include temperature, pH, fecal coliform, and DO. Lacamas Creek and several tributaries were listed on the 1998 state 303(d) list for exceedances of water quality standards (WDOE 1998). Lacamas Creek below Round Lake has elevated DO and temperature. In the 1970s, Lacamas Lake was identified as having eutrophication problems due to phosphorous loading. The Lacamas Lake Restoration Project has assisted many landowners with the adoption of agricultural Best Management Practices in order to correct this problem (Wade 2001).

Water temperatures consistently exceeded 64°F (17.8°C) during the summer at the Washougal Salmon Hatchery between 1987 and 1991. The Clark Skamania Flyfishers and Washington Trout staff measured high water temperatures in several upper basin tributaries between 1997 and 1999. Exposed bedrock, low flows, poor riparian canopy cover, and livestock watering detention systems are suspected of contributing to elevated water temperatures. Though only limited data exists, water temperatures in the lower river are also believed to be high. Elevated turbidity is seen as a potential problem in the Little Washougal, Jones, and Dougan Creeks (Wade 2001).

Historically, discharges from the paper mill created water quality problems in the Camas Slough. As late as the 1960s, concern over sulfite discharges led to the release of fish from the salmon hatchery on vacation weekends when the mill was closed (WDF 1990). Wastewater is now treated at facilities on Lady's Island though pollutants that have accumulated in sediments could still be a problem. There is also a concern about the Skamania and Washougal Salmon Hatcheries' release of potentially harmful effluent containing antibiotics and diseases (Wade 2001).

Nutrient levels are believed to be limited due to the lack of salmon carcasses as a result of low escapement levels for most species.

15.5.4 Key Habitat

Though little monitoring data exists, observations indicate that adequate pool habitat is generally lacking throughout the basin due to low large woody debris (LWD) concentrations and past channel scouring from splash-dam logging. Only a few, bedrock-formed, pools are located on the lower and middle mainstem, however, low flows and recreational use limits the ability of these pools to provide adequate steelhead rearing and adult holding. Pool abundance and quality is considered poor in the Little Washougal, Jones Creek, Boulder Creek, NF Washougal, and EF Washougal (Wade 2001).

Side channel habitat is similarly lacking, especially on the lower mainstem that has received extensive diking and riprap. Wade (2001) outlines several areas where decent side channel habitat exists and where there may be potential to restore historical off-channel habitats. Due to steep gradients and natural confinement, very little side channel habitat was ever available in the upper basin, with only a few exceptions. The Salmon Hatchery at RM 20 apparently is situated on a historical wetland from which it currently diverts water. There may be some side channel restoration potential at this site (Wade 2001).

Habitat unit fragmentation may result from the high number of stream crossings in portions of the basin. The Little Washougal, Upper Washougal, and Silverstar basins have over 6 stream crossings per square mile, potentially reducing channel complexity and altering sediment routing processes (Wade 2001).

15.5.5 Substrate & Sediment

Many reports mention a lack of spawning gravel as a major limiting factor in the Washougal basin. In the lower reaches, gravel was actually mined from the channel. In the rest of the basin, lack of gravel is attributed to removal of LWD, splash damming, and the hydrologic effects of the Yacolt Burn (1902) and logging. Much of the middle and upper mainstem consists of bedrock and boulder dominated channels. Dams on Lacamas and Wildboy Creeks have eliminated spawning gravel recruitment to downstream reaches (Wade 2001).

Sediment production may be elevated in some areas due to high (> 3 mi/mi^2) road densities, stream-adjacent roads, recreational vehicle use, vegetation removal, residential development, and cattle impacts to stream banks. Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. Nineteen of the 29 subwatersheds were given a rating of “moderately impaired” with respect to conditions influencing sediment supply; the remainder were rated as “functional”. High road densities on steep slopes and/or unstable soils are the primary driver of impaired conditions.

Although the overall road density is moderate (2.65 mi/mi^2), high road densities exist in the Lacamas Creek basin (3.28 mi/mi^2) and the little Washougal basin (3.36 mi/mi^2). The proliferation of stream-adjacent roads (29 miles within the Little Washougal alone) may also increase sediment delivery. Recreational vehicle access to powerline corridors and off-limit trails is seen as a potential source of fine sediment delivery to streams. Clearing of vegetation through logging or other practices is believed to increase sediment production throughout the watershed, particularly at sites in the Dougan Creek and Jones Creek basins. Residential development is suspected of increasing sediment accumulations in the Little Washougal basin and cattle impacts may be contributing fine sediments to Winkler Creek (Wade 2001).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

15.5.6 Woody Debris

Low quantities of LWD throughout the system are attributed to splash damming, past active removal, and low recruitment potential due to fires and logging. Quantities are especially low in the Little Washougal River. Portions of the upper Little Washougal, upper mainstem, and upper West Fork have riparian forests that are in good condition and may deliver much-needed LWD to streams in the near future (Wade 2001).

15.5.7 Channel Stability

Bank stability is generally considered good throughout the watershed though isolated areas of instability exist. A large, unstable hillside downstream from the Vernon Road Bridge appears to be associated with a road cut and subsequent clearing of vegetation. It is believed that a slide here could present a significant risk to river habitats though the immediacy of the problem is unknown. Other areas of instability are associated with motor-cross activities, cattle access, failed culverts, and vegetation removal. A complete description can be found in the Limiting Factors Analysis (Wade 2001). In some instances, increased erosion may be providing needed spawning gravels to downstream channels.

15.5.8 Riparian Function

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 7 of the 29 subwatersheds have "impaired" riparian conditions,18 are "moderately impaired", and 4 are "functional". The greatest impairments are located along the lower mainstem and in the Lacamas Creek basin, whereas functional conditions are located in the headwaters of the mainstem and the West Fork.

Riparian forests along the lower mainstem and the Camas Slough have been cleared for industrial uses, residential uses, and road corridors and only a few places contain native deciduous species. Conditions improve as you move up the basin, except in portions of the West Fork and Dougan Creek, which are still recovering from past fires. Riparian conditions in Boulder, Jones, EF Jones, Winkler Creek, and Texas Creek are considered poor (Wade 2001).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

15.5.9 Floodplain Function

Past splash damming, logging, and reduced vegetation cover following the Yacolt Burn (1902) has resulted in channel scour and incision in many places on the mainstem, creating a channel that is disconnected with its floodplain and side-channel habitats. This reduction in habitat may be impacting overwinter survival of some species (Wade 2001).

Much of the lower mainstem (including Camas Slough) and the lower Little Washougal have experienced floodplain and side channel loss due to diking and channelization associated with industrial, transportation, residential, mining, and agricultural activities. The lower reach extending from the mouth to the Little Washougal River (RM 5.6) has been especially impacted by past and on-going floodplain development. Channel incision has also been observed in many of these areas. Wade (2001) provides an in-depth description of the location of channelization features.

15.6 Fish/Habitat Assessments

The previous descriptions of fish habitat conditions can help identify general problems but do not provide sufficient detail to determine the magnitude of change needed to affect recovery or to prioritize specific habitat restoration activities. A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Washougal River winter steelhead, summer steelhead, chum, coho and fall chinook. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Volume VI.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

15.6.1 Population Analysis

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the Washougal River subbasin for chum, fall chinook, coho, winter steelhead, and summer steelhead. For all modeled populations, adult productivity has declined sharply from historical levels (Table 15-1). Fall chinook productivity has declined by 63%, while chum, coho, winter steelhead, and summer steelhead productivities have declined by 85%, 80%, 89%, and 79%, respectively. Adult abundance has also decreased for all species (Figure 15-9). The decline in abundance has been least for fall chinook, currently at 53% of historical levels, and most severe for chum, currently at 4% of historical levels. Species diversity (as measured by the diversity index) has remained relatively stable for fall chinook and summer steelhead (Table 15-1), while declining anywhere from 30-50% for the rest of the species.

Trends in both smolt productivity and smolt abundance are similar, with current estimates far below historical levels (Table 15-1). Coho and winter steelhead have seen the largest decline in smolt productivity, to 17 and 20% of historical levels, respectively. Chum and coho have seen the largest decline in smolt abundance, to 7% and 18% of historical levels, respectively.

Model results indicate that restoration of properly functioning (PFC) habitat conditions throughout the basin would significantly benefit all species (Table 15-1). Restoration of PFC would provide the greatest benefit to chum and coho. Adult chum abundance would increase over 450% from current levels, while adult coho abundance would increase over 300% from current levels. Similarly, chum smolt abundance would increase over 550% from current levels, while coho smolt abundance would increase over 380% from current levels.

Table 15-1. Washougal subbasin— Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]	P	PFC	T[1]
Fall Chinook	1,624	2,810	3,037	3.8	8.0	10.2	0.96	1.00	1.00	282,145	507,734	559,240	488	971	1,221
Chum	699	3,971	18,072	1.6	7.1	10.5	0.69	1.00	1.00	338,274	2,255,690	4,703,217	532	1,024	1,175
Coho	824	3,362	3,934	2.2	7.6	10.5	0.47	0.89	0.98	19,934	96,963	113,303	51	211	293
Winter Steelhead	500	909	1,947	3.8	12.6	33.8	0.72	1.00	1.00	7,065	13,699	15,906	69	242	352
Summer Steelhead	639	876	2,177	4.3	6.7	20.5	0.95	1.00	1.00	12,035	15,871	21,187	81	122	200

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

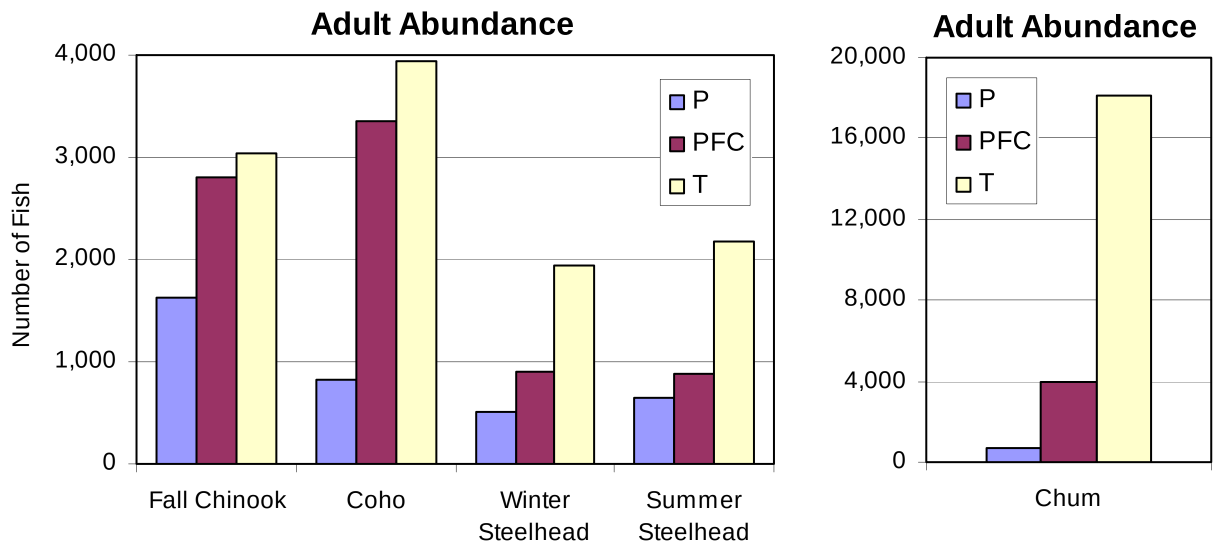


Figure 15-9. Adult abundance of Kalama fall chinook, spring chinook, coho, winter steelhead, summer steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

15.6.2 Restoration and Preservation Analysis

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Summer steelhead, which are able to ascend Dougan Falls at RM 22, utilize the greatest portion of subbasin reaches. Winter steelhead make extensive use of the lower and middle mainstem and tributaries. In order to avoid spurious results in EDT modeling, winter and summer steelhead were identified as using non-overlapping reaches during critical life stages. In reality, there is more overlap between these populations than is suggested by the reach priority results. Fall chinook primarily use the lower mainstem and major tributaries, whereas chum historically used only the lower few mainstem reaches. See Figure 15-10 for a map of EDT reaches within the Washougal subbasin.

For summer steelhead, high priority reaches lie in the upper (Washougal 14-16) and headwater (Washougal 17) sections, as well as in the lower WF Washougal (WF Washougal 1B and 2) (Figure 15-11). These areas provide significant spawning and rearing habitats. All high priority reaches, except Washougal 1B, show a habitat preservation emphasis. Washougal 1B shows a combined preservation and restoration emphasis.

High priority winter steelhead reaches include sections of the lower mainstem (Washougal 5), lower WF Washougal (WF Washougal 1), and the Little Washougal (Figure 15-12). These areas encompass the primary winter steelhead spawning and rearing sites. The majority of these reaches show a habitat restoration emphasis, however, the reaches of the lower Little Washougal (Little Washougal 1-3) show a combined habitat preservation and restoration emphasis.

Important reaches for fall chinook are primarily located in the lower and middle mainstem areas (Washougal 3- 9) (Figure 15-13). Reach Washougal 3 has the highest restoration value of any fall chinook reach, while reach Washougal 9 has the highest preservation value for any fall chinook reach.

Chum, although functionally extinct from the subbasin, have high priority reaches located in the extreme lower sections of the mainstem (Washougal tidal 1 and 2) (Figure 15-14). These reaches show a strong habitat restoration emphasis. It is important to note that Lower Lacamas Creek, although not included in this model run, has recently been found to contain chum (Rawding pers. comm. 2002), and should therefore be considered for restoration efforts.

High priority reaches for coho are located in sections of the lower (Washougal 3 and 4), middle (Washougal 8 and 9), and Little Washougal (Little Washougal 2C and 2E) (Figure 15-15). The majority of modeled coho reaches show a strong habitat restoration emphasis, with Little Washougal 2E having the highest restoration value of any coho reach.

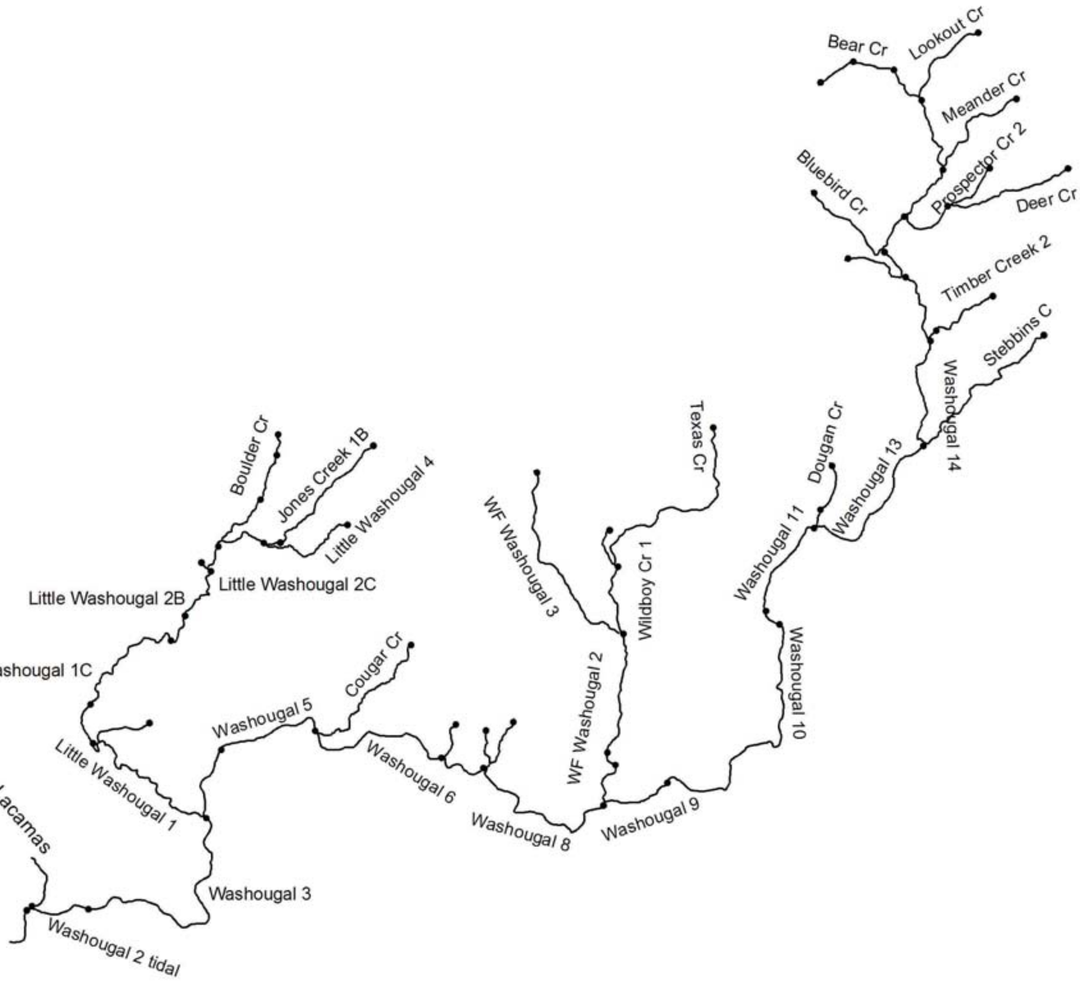


Figure 15-10. Washougal subbasin EDT reaches. Some reaches are not labeled for clarity.

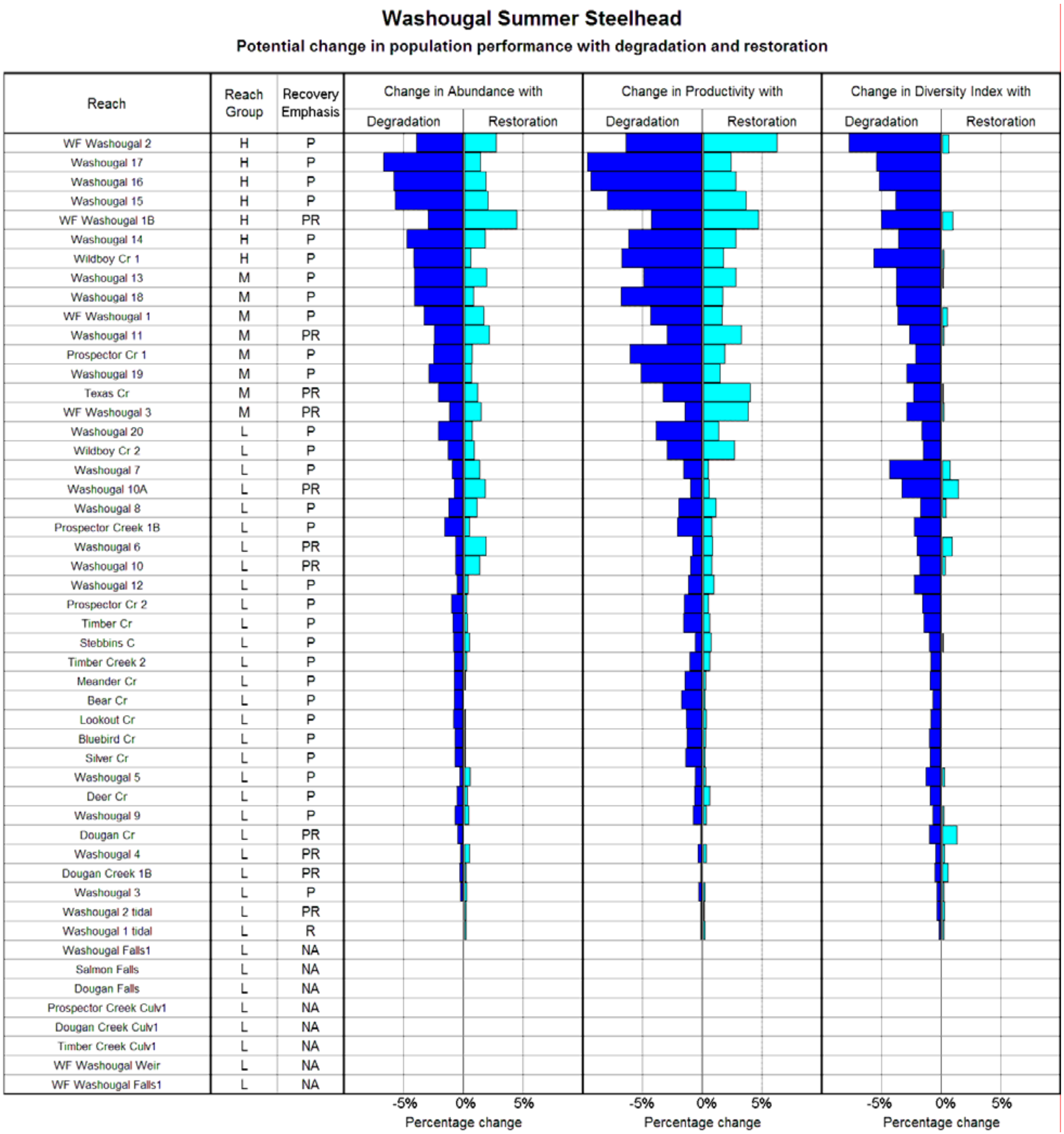


Figure 15-11. Washougal subbasin summer steelhead ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Volume VI for more information on EDT ladder diagrams.

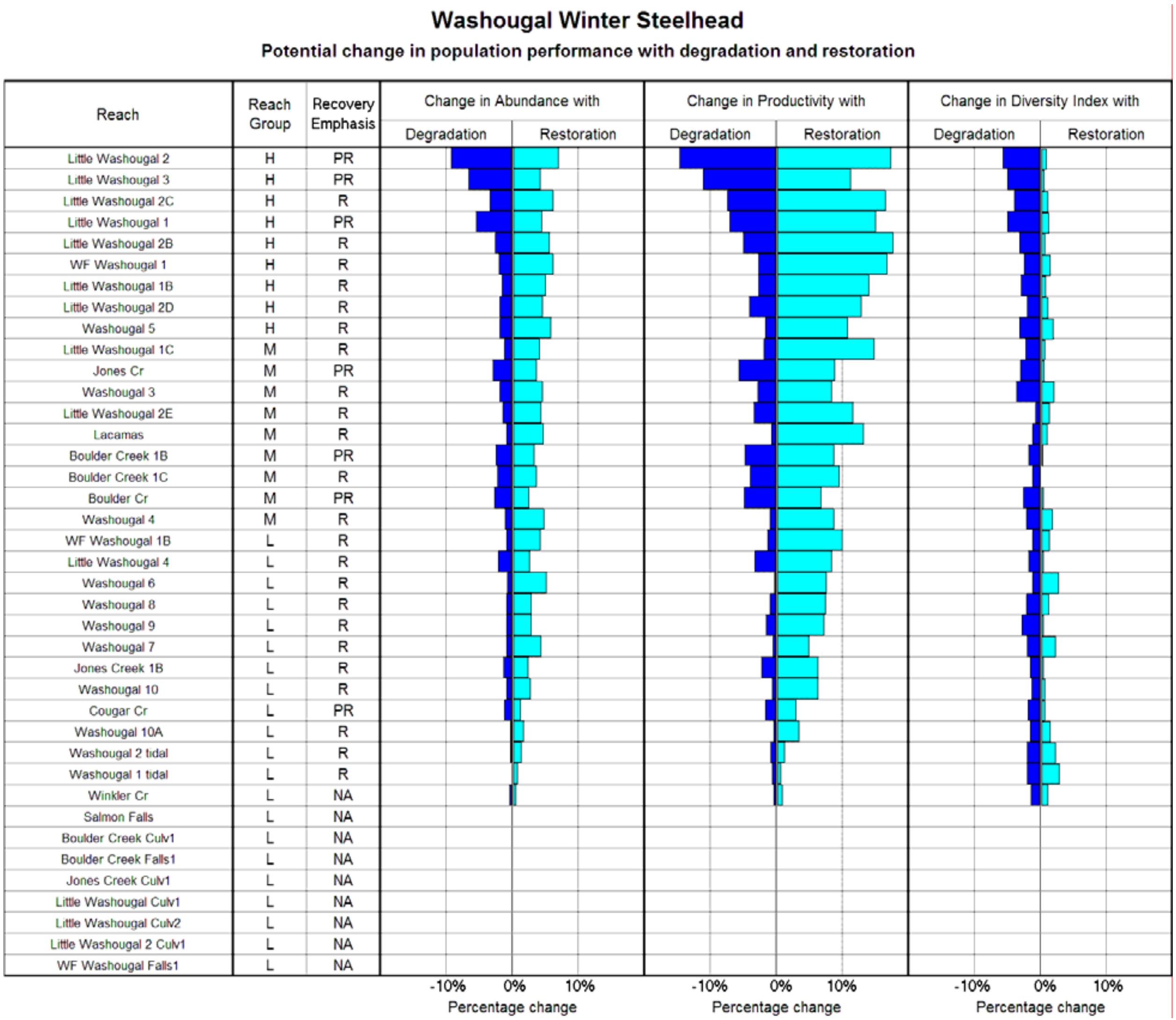


Figure 15-12. Washougal subbasin winter steelhead ladder diagram.

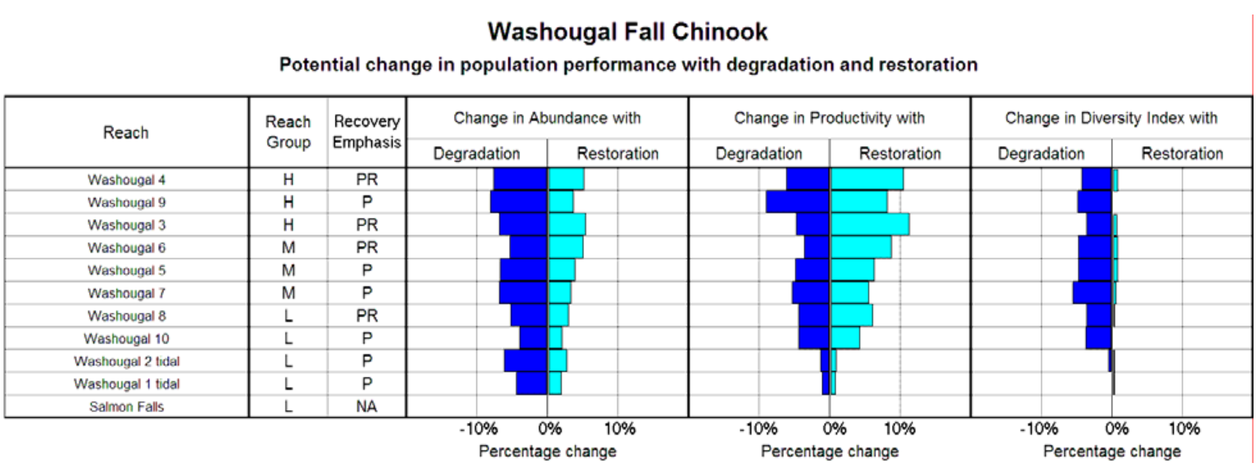


Figure 15-13. Washougal subbasin fall chinook ladder diagram.

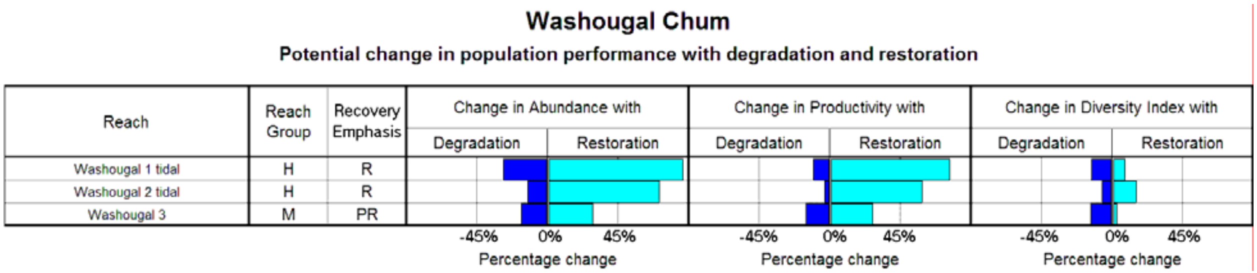


Figure 15-14. Washougal subbasin chum ladder diagram.

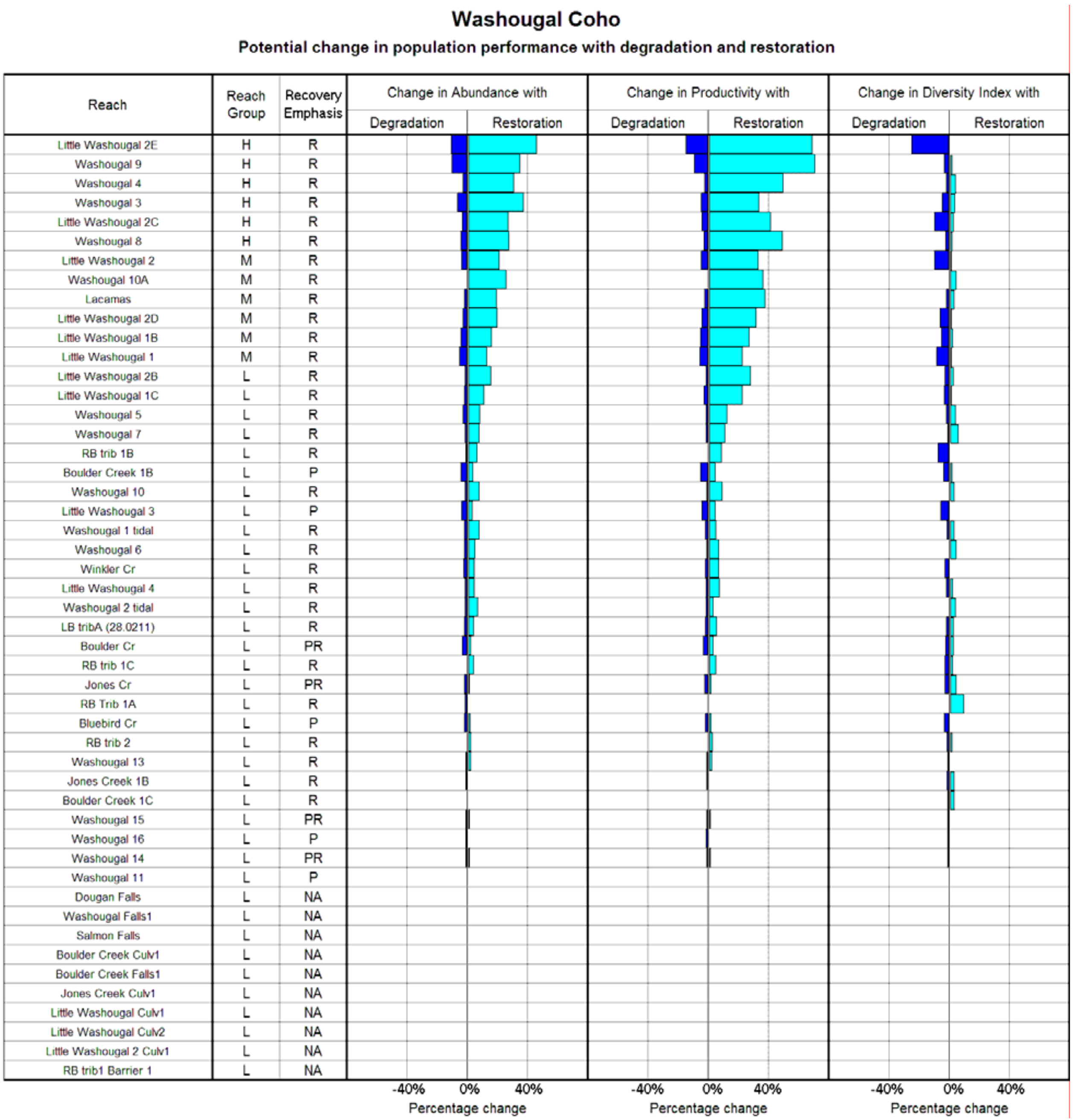


Figure 15-15. Washougal subbasin coho ladder diagram.

15.6.3 Habitat Factor Analysis

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the reach analysis compares current/patient and historical/template habitat conditions. The figures generated by habitat factor analysis display the relative impact of habitat factors in specific reaches. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

As described previously, the greatest restoration potential for Washougal summer steelhead is in the upper mainstem, with substantial benefits also gained by restoring habitat in the WF Washougal. In these reaches, the greatest impacts to summer steelhead appear to be from a loss of habitat diversity, altered temperature and flow regimes, and sedimentation (Figure 15-16). Habitat diversity in these reaches is primarily impacted by a lack of instream LWD and degraded riparian function. Severe burns in the early and mid 20th century, combined with subsequent intense logging, have reduced the recruitment rate of stable LWD. In addition, some of these reaches may still be recovering from splash damming that scoured channels and reduced bank stability. Impacts to the flow regime are primarily a result of the high road density (>3 mi/mi^2) in some subwatersheds as well as the lack of mature forest cover. Degraded riparian conditions, scoured channels, and lack of large woody debris contribute to the degraded channel stability, key habitat, and food in these reaches. The headwater reaches (Washougal 16-20) suffer from many of the same impacts as the upper Washougal reaches. These headwater reaches, however, are less affected by flow regime changes due to a roadless basin upstream of reaches 19 and 20. Furthermore, in the last couple of years, the WDNR has obliterated many roads in the upper basin, resulting in a substantial reduction of road densities in the basin upstream of reach 16. Sediment and flow conditions are expected to improve as these areas recover.

In contrast to summer steelhead restoration priorities, restoration of winter steelhead habitat should focus on the lower Washougal and lower Little Washougal reaches. Sedimentation, temperature, and key habitat are the primary factors limiting performance of winter steelhead in the Washougal (Figure 15-17). Denuded riparian vegetation at streamside residences and along the highway that parallels the river contributes to these impacts, as does a general lack of instream LWD. Flow impacts arising from upper basin road and vegetation conditions are also a concern. Furthermore, there is a large amount of agricultural land along the lower Little Washougal and reaches suffer from low stream shade, low instream LWD, and sedimentation.

Restoration efforts for fall chinook should focus foremost on restoring channel stability, habitat diversity, sediment, and temperature conditions in the lower and middle mainstem (Figure 15-18). Sediment from upper basin sources settles out in low gradient portions of these reaches, which are important chinook spawning areas. Low LWD levels affect habitat diversity and channel stability. Channel stability is further impacted by changes to the flow regime. Many of these lower mainstem reaches suffer from bed scour. Riparian canopy cover (shade) has been reduced within the residential/highway corridor that follows the west bank of the lower river, thus increasing temperatures. Relatively minor impacts of predation, competition, and pathogens are related to the Washougal Hatchery program.

Chum salmon habitat in the lower river suffers from a lack of habitat diversity, increased sedimentation, and harassment (Figure 15-19). Habitat diversity has been lost due to low LWD levels and artificial confinement. Sediment impacts stem from upper basin sources, as the sediment tends to settle out in these lower portions of the basin. Harassment is due to the hatchery program and angling for hatchery fish.

Coho habitat in the Washougal subbasin is impacted by impaired conditions related to sediment, habitat diversity, key habitat, temperature, and channel stability (Figure 15-20). The causes of these impacts are similar to those discussed above for the other species.

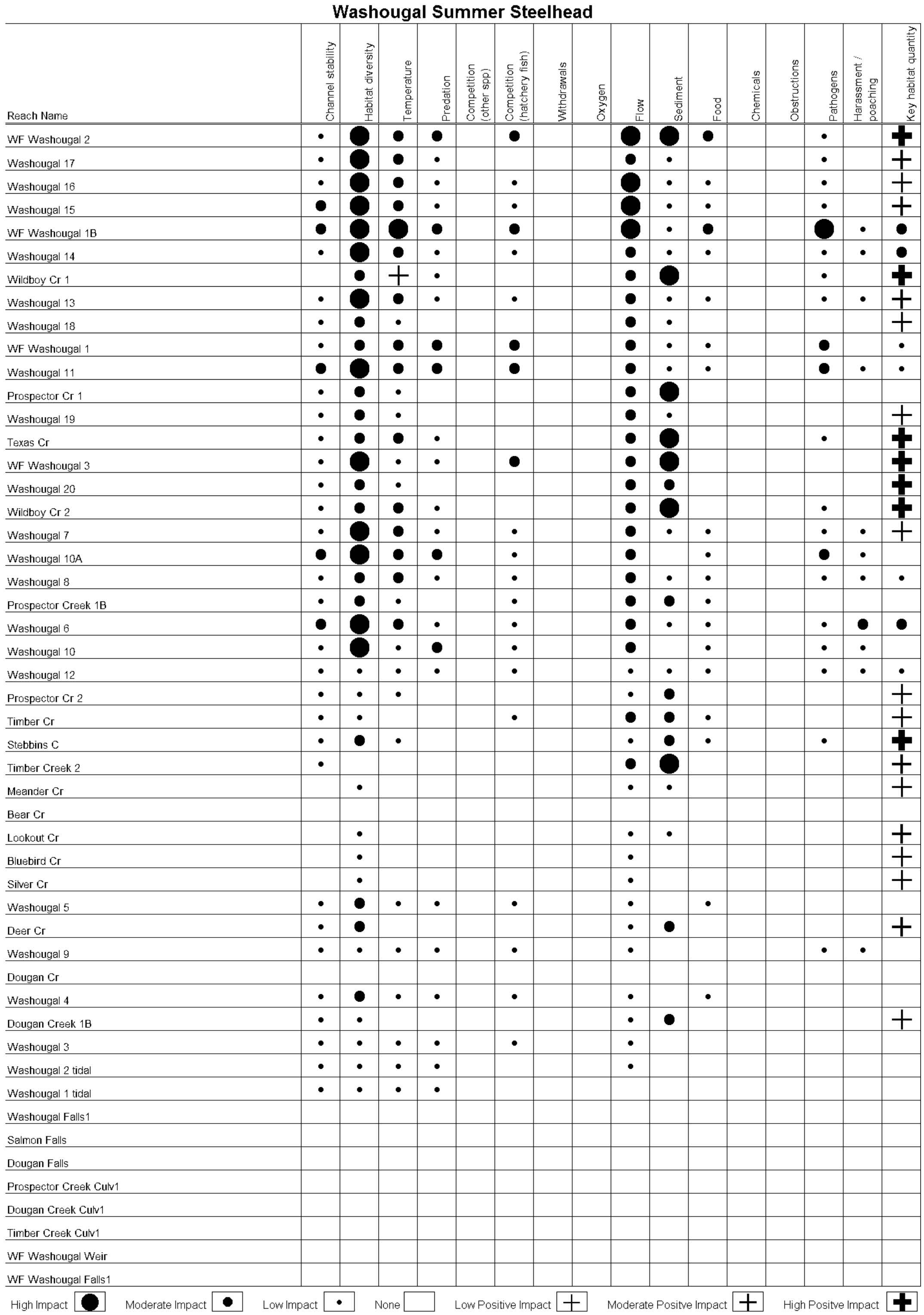


Figure 15-16. Washougal subbasin summer steelhead habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Volume VI for more information on habitat factor analysis diagrams.

Washougal Winter Steelhead

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Little Washougal 2	•	●	⬤	•					●	●	•			●		•
Little Washougal 3	•	●	●	•					●	●				•		•
Little Washougal 2C	•	•	⬤	•					●	⬤	•			•		●
Little Washougal 1	•	•	●	●		•			●	●	•			•		⬤
Little Washougal 2B	•	●	⬤	•		•			●	⬤	•			•		⬤
WF Washougal 1	•	•	⬤	●		•			●	⬤	•			●		●
Little Washougal 1B	•	•	⬤	•		•			●	●	•			•	•	●
Little Washougal 2D	•	•	⬤	•					●	⬤	•			•		⬤
Washougal 5	•	●	●	●		•			●	●	•			•		
Little Washougal 1C	•	•	●	•		•			●	●	•			•	•	⬤
Jones Cr	•	•	●	•		•			●	⬤	•			•		●
Washougal 3	•	●	●	●	•	•			●	●	•			•		•
Little Washougal 2E	•		⬤						•	⬤						●
Lacamas	•	•	⬤	●					•	⬤	•			●		●
Boulder Creek 1B		•	●	•		•			●	⬤	•			•		⬤
Boulder Creek 1C		•	⬤	•					•	⬤	•			•		⬤
Boulder Cr		•	●	•					●	⬤	•			•		●
Washougal 4	•	●	●	•		•			●	●	•			•	•	•
WF Washougal 1B	•	●	●	•		•			●	⬤	•			•		●
Little Washougal 4	•	•	●						●	⬤				•		⬤
Washougal 6	•	⬤	●	•		•			●	●	•			•		•
Washougal 8	•	●	●	•		•			•	●	•			•		•
Washougal 9	•	•	●	•		•			•	●	•			•	•	
Washougal 7	•	●	●	•		•			●	●	•			•		•
Jones Creek 1B	•	•	●						●	●	•					⬤
Washougal 10	•	●	●	•		•			•	•	•			•		●
Cougar Cr		•	●						•	●						⬤
Washougal 10A	•	●	●	•		•			•	•				•		•
Washougal 2 tidal	•	●	•	•		•			•		•			•		
Washougal 1 tidal	•	•	•	•		•			•					•		
Winkler Cr			•						•	•						+
Salmon Falls																
Boulder Creek Culv1																
Boulder Creek Falls1																
Jones Creek Culv1																
Little Washougal Culv1																
Little Washougal Culv2																
Little Washougal 2 Culv1																
WF Washougal Falls1																

High Impact ⬤ Moderate Impact ● Low Impact • None Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 15-17. Washougal subbasin winter steelhead habitat factor analysis diagram.

Washougal Fall Chinook

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Washougal 4	Moderate	Moderate	Moderate	Low		Low			Low	Moderate	Low				Low	Low
Washougal 9	Moderate	Low	Moderate	Low					Low	High	Low				Low	Low
Washougal 3	Moderate	Moderate	Moderate	Low	Low	Low			Low	High	Moderate				Low	Low
Washougal 6	Moderate	Moderate	Moderate	Low					Moderate	Moderate	Low				Low	Moderate
Washougal 5	Moderate	Moderate	Moderate	Low		Low			Low	Moderate	Low				Low	Moderate
Washougal 7	Moderate	Moderate	Moderate	Low					Low	Moderate	Low				Low	Moderate
Washougal 8	Moderate	Moderate	Moderate	Low					Low	Moderate	Low				Low	Low
Washougal 10	Moderate	Moderate	Low	Low					Low	Low	Low				Low	Moderate
Washougal 2 tidal	Moderate	Moderate	Low	Moderate	Low	Low			Low	Low	Moderate				Low	Low
Washougal 1 tidal	Low	Low	Low	Moderate	Low	Low			Low	Low	Low				Low	Low
Salmon Falls																

High Impact ● Moderate Impact • Low Impact · None Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 15-18. Washougal subbasin fall chinook habitat factor analysis diagram.

Washougal Chum

Reach Name	Channel stability	Habitat diversity	Temperature	Predation	Competition (other spp)	Competition (hatchery fish)	Withdrawals	Oxygen	Flow	Sediment	Food	Chemicals	Obstructions	Pathogens	Harassment / poaching	Key habitat quantity
Washougal 1 tidal	Moderate	Moderate		Moderate	Low				Low	Moderate	Low				Moderate	Moderate
Washougal 2 tidal	Low	Moderate		Low	Low				Low	Moderate	Low				Moderate	Low
Washougal 3	Low	Moderate		Low					Low	Moderate	Low				Moderate	Low Positive

High Impact ● Moderate Impact • Low Impact · None Low Positive Impact + Moderate Positve Impact + High Positve Impact ✚

Figure 15-19. Washougal subbasin chum habitat factor analysis diagram.

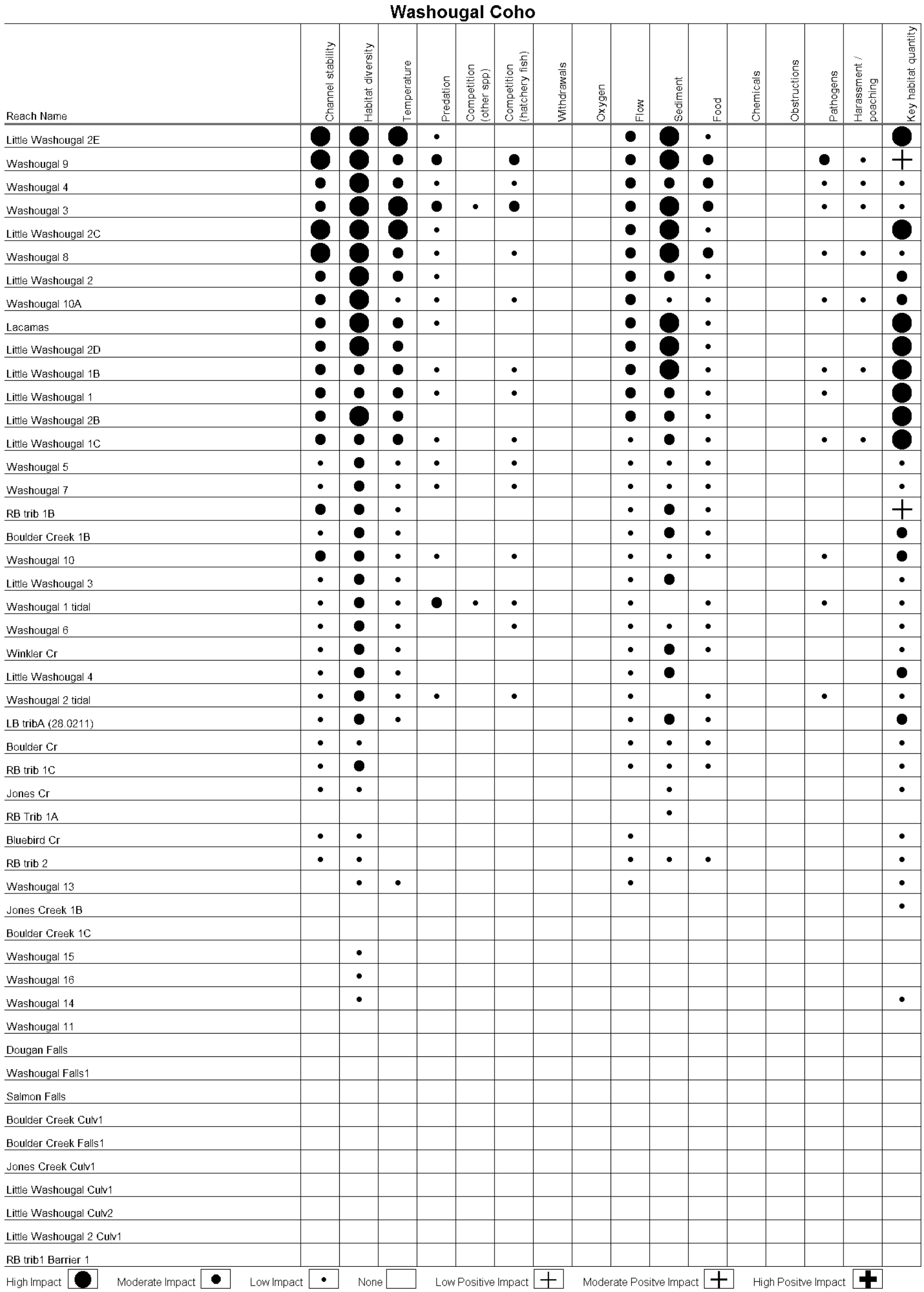


Figure 15-20. Washougal subbasin coho habitat factor analysis diagram.

15.7 Integrated Watershed Assessments (IWA)

The Washougal River watershed comprises 29 subwatersheds covering a total of approximately 137,600 acres. The Washougal River watershed is primarily a lower elevation, rain dominated system with low to moderate levels of natural erodability. Nine subwatersheds are considered headwaters, with high elevation types and low to moderate erodability; the majority of these are predominantly in the rain-on-snow zone. Thirteen subwatersheds are the low elevation tributary type, with low to moderate erodability levels. The seven mainstem river subwatersheds can be divided into three moderate size mainstem river types (between 20,000 and 200,000 acres total drainage area), and four low elevation moderate - sized mainstem river types. Natural erodability in these seven mainstem subwatersheds is classified as low to moderate.

15.7.1 Results and Discussion

IWA results were calculated for all subwatersheds in the Washougal River watershed. IWA results are calculated at the local level (i.e., within subwatershed, not considering upstream effects) and the watershed level (i.e., integrating the effects of the entire upstream drainage area as well as local effects). A summary of the results is shown in. IWA results for each subwatershed are presented in Table 15-2. A reference map showing the location of each subwatershed in the basin is presented in Figure 15-21. Maps of the distribution of local and watershed level IWA results are displayed in Figure 15-22.

Table 15-2. IWA results for the Washougal River watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
60101	F	M	F	F	M	60103
60102	F	F	F	F	F	none
60103	F	M	M	F	M	none
60201	M	M	M	F	M	60101, 60102, 60103, 60202, 60204
60202	F	M	F	F	M	none
60203	I	M	M	I	M	none
60204	F	F	M	F	F	none
60301	M	F	M	I	M	60302, 60303, 60304
60302	M	F	M	M	F	none
60303	I	M	M	I	M	none
60401	I	M	M	M	M	60101, 60102, 60103, 60201, 60202, 60203, 60204
60402	I	M	M	I	M	none
60501	I	M	I	I	M	60101, 60102, 60103, 60502, 60503, 60504, 60505, 60506, 60401, 60402, 60201, 60202, 60203, 60204, 60301, 60302, 60303, 60304
60502	I	M	M	I	M	60503, 60506
60503	M	F	M	M	F	none

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
60504	I	M	M	I	M	60101, 60102, 60103, 60401, 60402, 60201, 60202, 60203, 60204, 60301, 60302, 60303, 60304
60505	I	M	M	I	M	none
60506	M	M	M	M	M	none
60601	I	M	I	M	M	60101, 60102, 60103, 60502, 60503, 60504, 60505, 60506, 60401, 60402, 60201, 60202, 60203, 60204, 60301, 60302, 60303, 60304, 60602, 60603, 60604, 60605, 60606, 60607, 60608, 60609, 60610
60602	M	F	M	I	M	60603, 60604, 60605, 60606, 60607, 60608, 60609, 60610
60603	M	F	I	I	M	60604, 60605, 60606, 60607, 60608, 60609, 60610
60604	I	M	I	I	M	none
60605	M	M	M	M	M	none
60606	I	M	M	I	M	none
60607	M	F	I	I	F	60608, 60609, 60610
60608	I	F	I	I	F	none
60609	I	M	I	I	M	none
60610	I	M	M	I	M	none

Notes:

[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800010#####.

[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:

F: Functional

M: Moderately impaired

I: Impaired

[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.

[d] Subwatersheds upstream from this subwatershed.

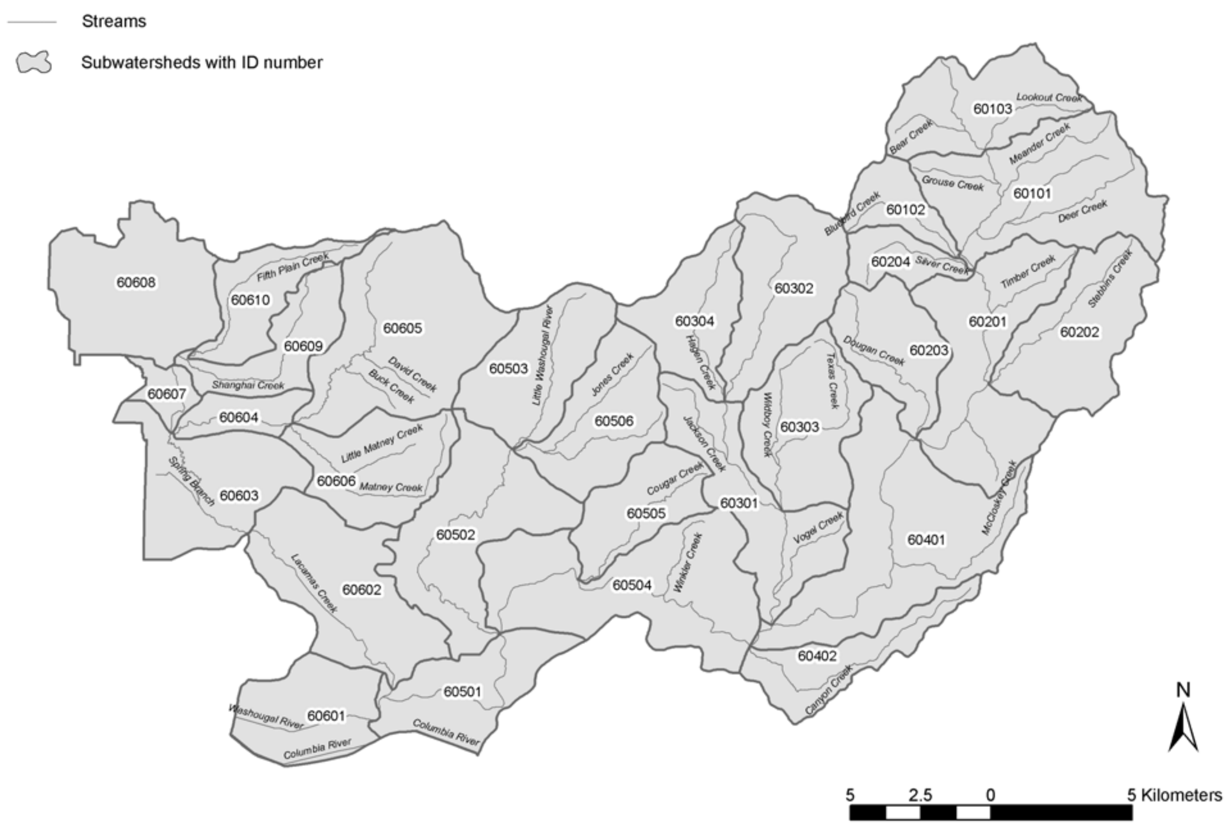


Figure 15-21. Map of the Washougal basin showing the location of the IWA subwatersheds.

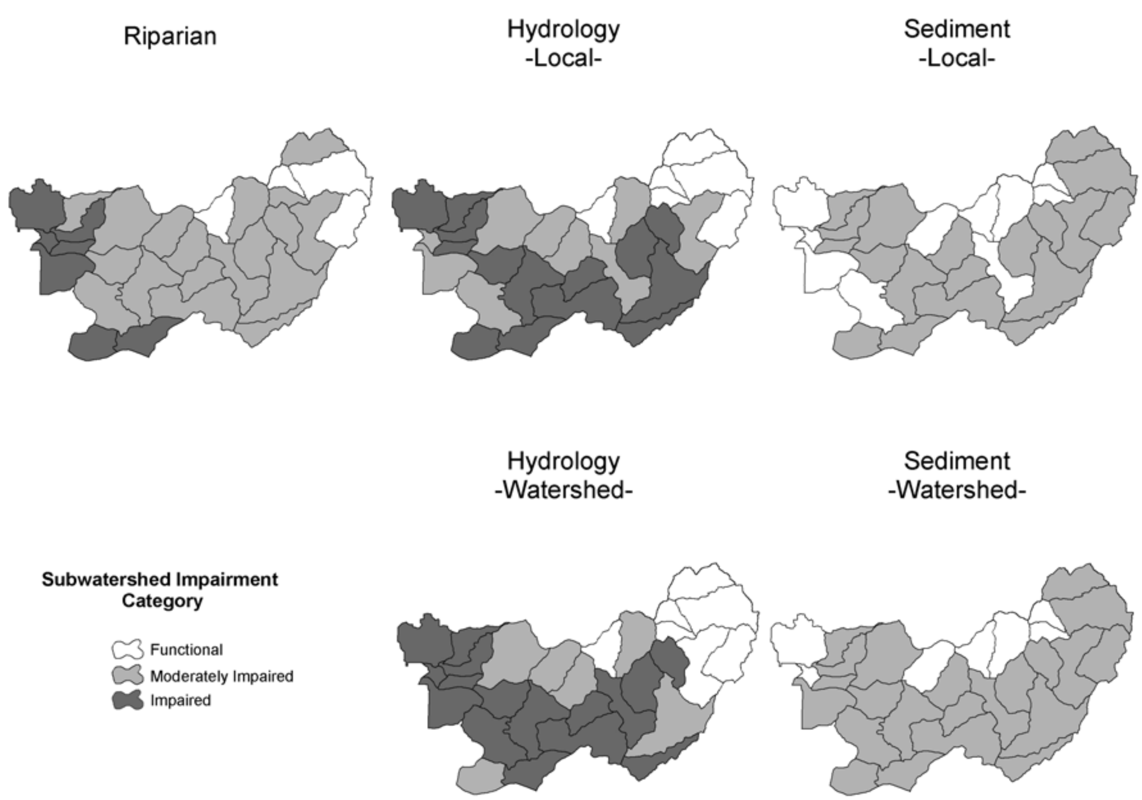


Figure 15-22. IWA subwatershed impairment ratings by category for the Washougal basin

15.7.1.1 Hydrology

Hydrologic conditions across the Washougal River watershed range from functional to impaired, with functional subwatersheds located in headwaters areas in the upper mainstem and upper West Fork. Conditions become increasingly impaired on a downstream gradient. Hydrologically impaired subwatersheds are primarily concentrated in the moderate to low elevation areas of the mainstem Washougal River and the lower Little Washougal River, as well as some tributary streams. An exception to this pattern is the Lacamas Creek drainage, which has several hydrologically impaired headwaters subwatersheds.

Hydrologically intact conditions in headwaters subwatersheds appear to buffer downstream conditions. These subwatersheds include the headwaters of the Washougal (60103), Bluebird Creek (60102), the upper mainstem (60101), Stebbins Creek (60202), Silver Creek (60204), and Hagen Creek in the West Fork Washougal headwaters (60304). The upper mainstem subwatershed (60101) is especially important for summer steelhead. The majority (90%) of the land area in these upper subwatersheds is publicly owned, and managed by either the USFS or WDNR. These subwatersheds are susceptible to potential hydrologic impacts because of high rain-on-snow area (72%). However, mature forest cover in these subwatersheds averages 69% and road densities are relatively low (all < 3 mi/mi^2).

Impaired watershed level conditions in the lower West Fork Washougal River (60301) are strongly influenced by impaired hydrologic conditions in the Wildboy Creek drainage (60303) and moderately impaired conditions locally and in the upper West Fork Washougal River (60302). Relatively intact hydrologic conditions in Hagen Creek (60304) appear to be an important buffer. The upper West Fork (60302) is primarily public lands (64%) administered by USFS or WDNR. However, current land cover conditions are poor, with only 21% of subwatershed area in hydrologically mature forest. The upper West Fork has 67% of its area in the rain-on-snow zone, and therefore is more sensitive to hydrologic degradation. Current road densities are moderate (2.1 mi/mi^2). Wildboy Creek is largely in private land holdings (81%), the majority being active timber lands. Mature forest cover is low (27%) and road densities are high (4.9 mi/mi^2).

The Cougar Creek drainage (60505) and the upper Little Washougal River (60506) are both terminal (i.e., no upstream subwatersheds) and relatively low elevation, with less than 25% of area in the rain-on-snow zone. They are almost evenly divided between public and private lands. Hydrologic conditions in the Cougar Creek drainage are impaired, because of relatively low mature forest cover (39%), and moderately high road densities (3.3 mi/mi^2). The majority of privately held lands, comprising nearly 50% of total area, are zoned for commercial forestry. Approximately 4% is zoned for development but currently vacant. The upper Little Washougal River (60506) is moderately impaired as a result of a high percentage of mature vegetation (64%) and public lands ownership (62%), but also high road densities (5.4 mi/mi^2).

The middle mainstem Washougal River subwatersheds (60201 and 60401) contain important habitat for multiple species. These subwatersheds are moderately impaired and impaired at the local level, respectively, but appear to be buffered by hydrologically functional upstream subwatersheds, resulting in functional and moderately impaired watershed level ratings, respectively. Degraded hydrologic conditions in the Dougan Creek drainage (60203) contribute to the moderately impaired watershed level rating in subwatershed 60401. With regard to local conditions, the majority of subwatershed 60201 is owned by WDNR, and currently has 63% mature forest cover. Road densities are relatively high (3.4 mi/mi^2). Approximately 56% of this subwatershed is in the rain-on-snow zone. Subwatershed 60401 is

26% publicly owned, has only 26% mature forest cover, and has relatively high road densities at 4.5 mi/mi^2. Approximately 31% of this subwatershed is in the rain-on-snow zone; 47% is publicly owned. Road densities are moderately high at 4.2 mi/mi^2, and hydrologically mature forest coverage is relatively low (37%). The remainder of land ownership in these two subwatersheds is primarily in private timber holdings.

Hydrologic conditions in the lower mainstem Washougal River (60504 and 60501) are rated as impaired at both the local and the watershed levels. Locally impaired ratings result primarily from high road densities, impervious surface, and poor forest cover associated with development within and surrounding the towns of Camas and Washougal. A high percentage of these subwatersheds (64%) is zoned for development but currently vacant. The lower mainstem Washougal River has been developed and channelized; impervious surface rates are increasing as development expands. Hydrologic conditions in these subwatersheds are also affected by impaired conditions in the West Fork and Little Washougal Rivers.

15.7.1.2 Sediment

The majority of subwatersheds have moderately impaired sediment supply conditions, with functional sediment conditions occurring mostly in headwaters tributaries, the lower West Fork Washougal (60301), and the lower Lacamas Creek drainage (60602, 60603). All sediment functional subwatersheds have very low natural erodability ratings, based on geology type and slope class, averaging less than 10 on a scale of 0-126. This suggests that these subwatersheds would not be large sources of sediment impacts under disturbed conditions. Road densities and streamside road densities in these subwatersheds are also relatively low. Moderately impaired sediment conditions are present in all subwatersheds important to anadromous fish. These problems are likely to be exacerbated in subwatersheds where hydrologic conditions are also impaired.

Four headwaters subwatersheds (60102, 60204, 60302 and 60304) have locally functional sediment conditions. Three of these, the upper Washougal (60102), Silver Creek (60204), and Hagen Creek (60304) are also rated hydrologically functional. These subwatersheds will buffer sediment conditions in important downstream subwatersheds.

Other headwaters and tributary subwatersheds have moderately impaired or impaired sediment conditions, including the Washougal headwaters (60103), Stebbins Creek (60202), Dougan Creek (60203) and Wildboy Creek (60303). All of these subwatersheds have low natural erodability ratings, ranging from 12-13, except for Dougan Creek which has a low moderate rating of 29. Road densities in Dougan and Wildboy Creeks exceed 4 mi/mi^2, and stream crossing density is also relatively high at 2.8 crossings/stream mile, leading to the hydrologically impaired rating. Stebbins Creek and the Washougal headwaters have lower road and stream crossing densities (2.7 and 1.1 mi/mi^2, and 2.0 and 0.3 crossings/stream mile, respectively). Streamside road density in the Washougal headwaters is very low.

Sediment conditions in the Cougar and Little Washougal subwatersheds (60505 and 60506) are moderately impaired. Natural erodability in these subwatersheds is quite low (less than 3); however, road densities in these subwatersheds contribute to moderate impairments. Moderate to high streamside road densities are additional sources of sediment in these watersheds.

Important mainstem subwatersheds in the Washougal system are all moderately impaired for sediment at both local and watershed levels. Consistent with the majority of the watershed, the natural erodability of these subwatersheds is relatively low (less than 27). The fact that functional sediment conditions fail to mitigate locally impaired conditions in downstream subwatersheds suggests that local sources are primary drivers. The WF Washougal (60301) has a moderately high density of streamside roads (0.5 miles/stream mile); however, many of these roads are surfaced county roads that contribute less sediment than unsurfaced roads.

15.7.1.3 Riparian

Moderately impaired riparian conditions predominate throughout the watershed, with only four functional subwatersheds in the headwaters of the mainstem and West Fork Washougal River. Impaired riparian conditions are present in five of nine subwatersheds in the Lacamas Creek drainage and in the developing subwatersheds around Washougal and Camas.

The four subwatersheds having functional riparian conditions (>80% functional riparian vegetation) include Hagen Creek (60304), Bluebird Creek (60102), Stebbins Creek (60202), and the upper mainstem Washougal (60101). These four subwatersheds are also rated hydrologically functional, and two (Bluebird Creek and Hagen Creek) are also functional for sediment.

Riparian conditions in all other subwatersheds are rated as moderately impaired, including the tributary subwatersheds of Cougar Creek (60505) and the headwaters of the Little Washougal River (60506).

15.7.2 Predicted Future Trends

15.7.2.1 Hydrology

Trends in hydrologic conditions are expected to remain stable or improve gradually in the headwaters subwatersheds (including 60101, 60102, 60103, 60202, 60204, Upper WF 60302, Wildboy Creek 60303, 60304). Hydrology trends in these subwatersheds are based on the high percentage of public lands, the low intensity of forest practices, and maturing of forest cover.

Hydrology conditions in the mainstem subwatersheds (60201 and 60401) are expected to trend stable because of the opposing effects of improving headwater conditions and locally high road densities. However, hydrologic conditions in Cougar Creek and the upper Little Washougal River may degrade further over the next 20 years because of the potential for development.

Given the high percentage of developable (i.e., zoned but currently vacant) land in the lower mainstem Washougal River (60504 and 60501), and the currently impaired conditions, the predicted trend is for hydrologic conditions to degrade further. This predicted trend also applies to the West Fork Washougal River (60301) because of continually increasing development adjacent to the stream channel.

15.7.2.2 Sediment Supply

Most sediment functional subwatersheds (i.e. headwaters) have been designated as such because of a high percentage of public land ownership and a relatively low level of current impacts; these conditions are not expected to change. Thus, the trend in sediment conditions for the current functional subwatersheds is expected to remain relatively constant over the next 20 years.

Most mid-elevation subwatersheds throughout the basin have moderately impaired sediment conditions; trends in sediment conditions are expected to be constant over the next 20 years. The predicted trend is based on the assumption that existing land uses will continue in the future (specifically, the likelihood for ongoing timber harvests on privately held lands and associated vehicle traffic on unsurfaced roads). Sediment conditions in these subwatersheds have the potential for improvement if timber harvests are limited.

Trends in sediment conditions in mainstem subwatersheds are expected to remain relatively constant (i.e. moderately impaired) or degrade further because of ongoing timber harvest on privately held lands, high road densities in upland areas, moderately high streamside road densities (ranging from 0.4 to 0.6 miles/stream mile), and the potential for increased development. Given the potential for development, sediment conditions in the Cougar, Little Washougal, and lower mainstem subwatersheds are susceptible to further degradation.

15.7.2.3 Riparian Condition

Currently functional riparian conditions in the upper watershed (Hagen Creek 60304, Bluebird Creek 60102, Stebbins Creek 60202, and the upper mainstem 60101) are expected to continue to improve over the next 20 years due to regulatory protections and functional hydrologic conditions.

The middle mainstem Washougal (60201, 60401) and the West Fork Washougal (60301) have large areas of public and private lands managed for timber harvest; the predicted trend in these subwatersheds is for riparian conditions to remain relatively constant. Some riparian recovery is expected on timber lands where streamside roads are not present, but these gains are expected to be offset by increasing streamside development (streamside road densities in these subwatersheds currently averages 0.5 miles/stream mile).

Riparian conditions in the lower mainstem Washougal (60504 and 60501) are expected to trend downward over the next 20 years, as development continues around the towns of Camas and Washougal. Channelization in these subwatersheds limits the potential for riparian recovery. Degrading riparian trends are also expected in Cougar Creek (60505), which has 24% of its area zoned for development but is currently vacant. Zoning information was not available for the Little Washougal headwaters (60506), but the proximity to other developable lands in the area suggests the potential for similar downward trends in riparian conditions.

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