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EDT Assessment of Aquatic Habitat in the Clackamas Subbasin

DRAFT

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Prepared by

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Clackamas River Salmonid Habitat Assessment

May 4, 2004

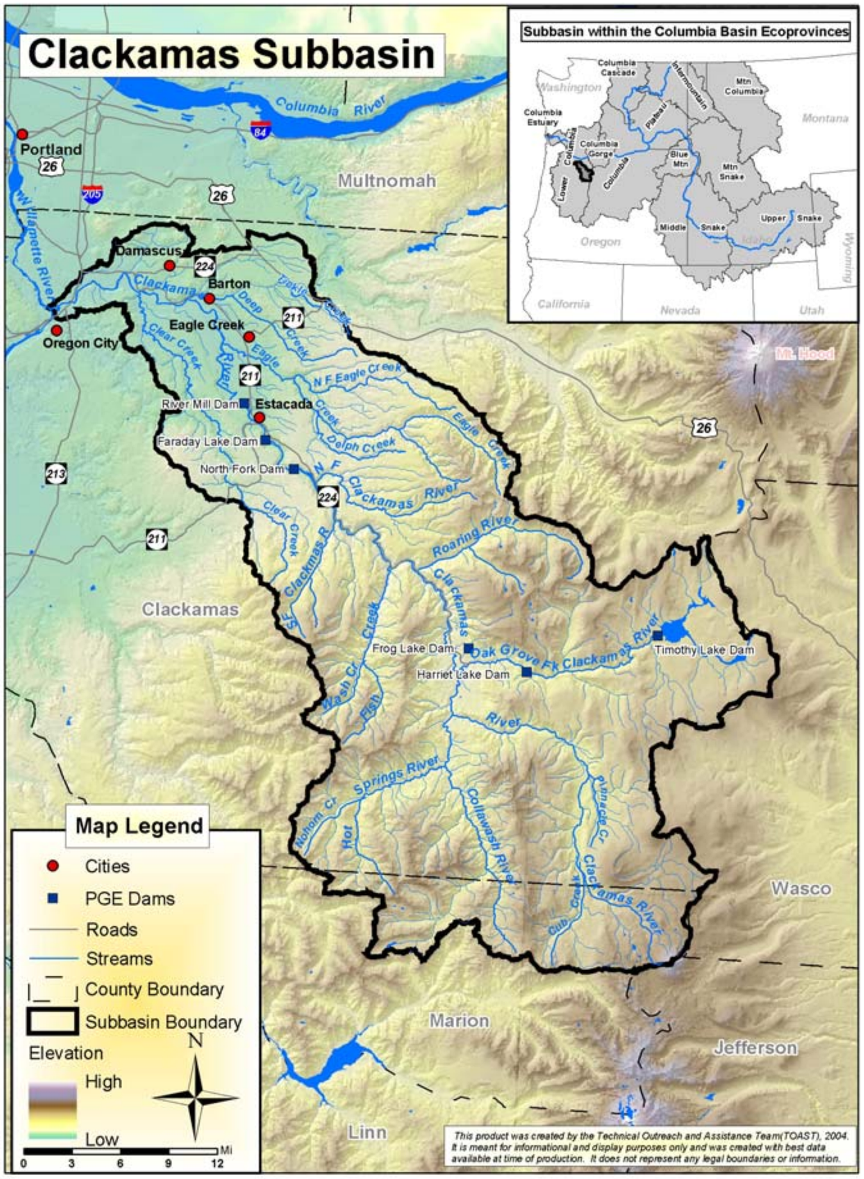
Geographic Setting

The Clackamas River drains a watershed of 941 sq. miles and is the fourth largest watershed within the Willamette basin. The Clackamas enters the Willamette at River Mile 25.1 and is the largest watershed in the Willamette River below Willamette Falls (mile 26.8). The river has several major tributaries, including Deep, Clear and Eagle creeks in the lower Clackamas and Collowash River and Oak Grove Fork in the upper basin (Figure 1). The upper two-thirds of the watershed consists of relatively high gradient, mountainous reaches while the lower section drains a gentler topography. The upper sections of the river are heavily forested and much of the upper watershed is within the Mt. Hood National Forest. The lower portion of the watershed is more developed and becomes increasingly urbanized at the mouth of the river. The city of Estacada is the largest city entirely within the watershed although the Portland suburbs of Glastone, Johnson City and Oregon City are located at the mouth of the river.

Portland General Electric (PGE) operates dams on the mainstem not far above the city of Estacada at Clackamas river mile 23. The PGE operation consists of River Mill Dam, Faraday Diversion Dam and North Fork Dam (Figure 1). These dams operate as a complex with the main reservoir located behind North Fork Dam. Migrating juvenile and adult fish are passed around these dams through a system of pipes and ladders (Cramer and Cramer 1994). PGE also operates a power production facility on the Oak Grove Fork. Harriet Lake Dam diverts most of the stream flow from Oak Grove out of the watershed to Three Lynx Powerhouse near Frog Lake. Anadromous fish passage is blocked below Harriet Lake Dam by a natural waterfall at River Mile 3.8 (USFS 1996).

The Clackamas River drains the lower east side of the Willamette Valley, which is a broad, north-south trending valley formed by the Coast Range to the west and the Cascade Mountains to the east. The floor of the valley has been filled by alluvial deposits of the Willamette drainage and by deposits from Missoula Floods that occured at the close of the last glaciation (Orr and others 1976). The Clackamas arises from the flanks of Mt. Hood in the Cascade Mountains in the High Cascades geological province (Orr and others 1976). This consists of relatively young volcanic deposits that have not yet developed a complete drainage network (Grant 1997). The rocks are highly porous and much of the area's precipitation is absorbed within the bedrock. This water is released through springs that maintain relatively high summer flow in the Clackamas compared to other streams in the Willamette (Grant 1997). As the river flows to the west, it drains the older Western Cascades province. These volcanic rocks are less porous and have a well-developed drainage network. Because of this, streamflow in the lower watershed largely track rainfall precipitation patterns (USFS 1995). The result is that summer flow in the upper Clackamas basin is relatively high compared to summer low flow in the lower basin (Figure 2).

Figure 1. Clackamas River watershed.

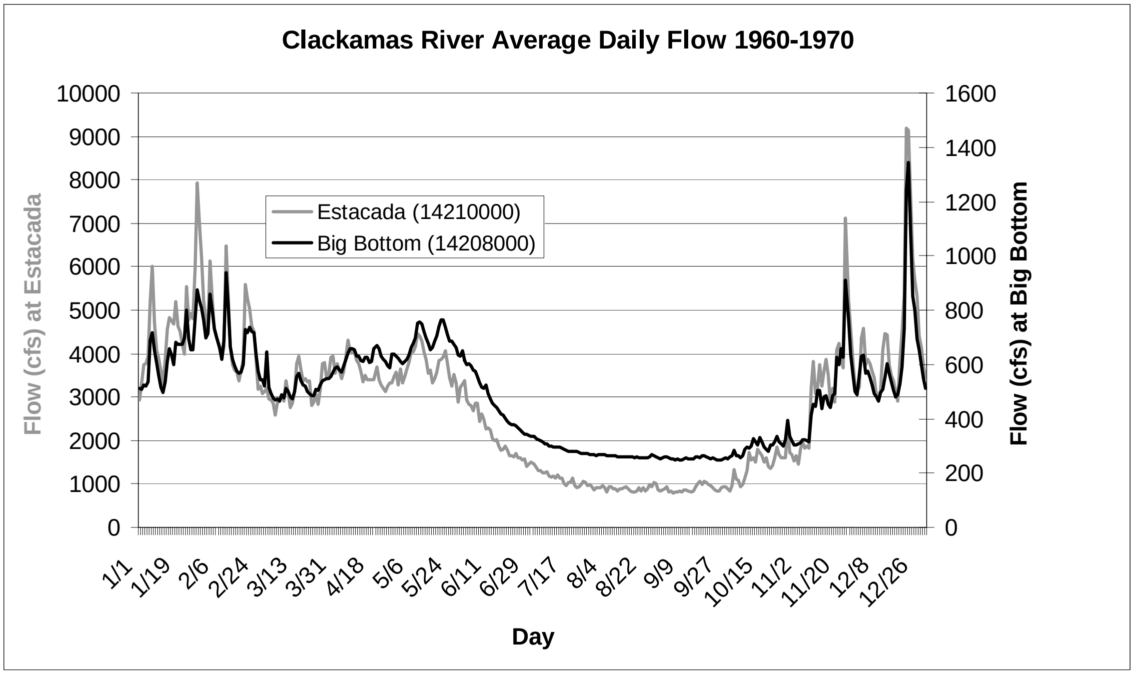


Key Findings

1. Current potential of habitat in the Clackamas River with respect to the six focal species is about 16 percent of that under the reference condition.

2. Habitat constraints in the Clackamas River are most severe in the lower portion of the river (below the PGE dams). As a result, most of the restoration opportunities in the Clackamas River lie in the lower reaches.

Figure 2. Flow in the Clackamas River in the upper watershed (Big Bottom) and lower watershed (Estacada). Period of record chosen to provide overlap in data.



3. Habitat in the upper basin (above the PGE dams) with the exception of the reaches inundated by the PGE dams is in relatively good shape; most protection opportunities, as a result, lie in the upper watershed.

4.

Description of the Analysis

General

The assessment of habitat conditions in the Clackamas River was made with regard to three native salmonid fish species: coho salmon, chinook salmon and steelhead trout. Ecosystem Diagnosis and Treatment (EDT) (Mobrand Biometrics 2004) was used as the primary assessment tool. EDT relates a reach level environmental description to the life stage and population performance of the focal species. The purpose of the assessment was threefold: 1) estimate the potential of the focal species in the Clackamas River given current habitat conditions, 2) prioritize areas within the Clackamas in regard to their potential protection and restoration value, and 3) identify specific factors constraining the current performance of the focal species in the Clackamas River.

The assessment was based on existing data sources including habitat assessments from the U.S. Forest Service, Oregon Department of Fish and Wildlife (ODFW), the Clackamas River Basin Council and others. Information was gathered and reviewed by a technical team composed of technical representatives from Clackamas County, ODFW, Portland General Electric (PGE) and the basin council.

EDT was used to characterize the potential biological performance of the focal species under two scenarios. The Current Condition was based on empirical data and expert observations of environmental conditions in the Clackamas River today. To provide a point of comparison, a Restored Reference Condition was developed. This is a representation of the Clackamas River in a fully restored condition and is analogous to a pre-settlement condition that might have existed in the early 19^{th} century. The intent, however, was not to recreate a specific historical condition but to describe the inherent potential of the system unencumbered by anthropogenic modifications. The change in potential performance of the focal species in the current condition relative to the idealized reference condition described the constraints on the system due to anthropogenic factors. A third scenario, the Degraded Condition, is automatically generated from EDT by setting most environmental attributes to a fully degraded condition. Conditions were assessed with respect to the focal species by comparing the current condition of the Clackamas at reach and larger scales to the Degraded and Restored conditions.

Following the assessment of conditions, we used EDT to characterize a fourth condition termed “PFC” or “Properly Functioning Conditions”. PFC is a set of attribute ratings in EDT that define an environmental condition that is consistent with productive salmon populations in the Pacific Northwest. The PFC condition lies between the Current condition and the Restored Reference condition. PFC conditions for EDT have been developed by an inter-agency team organized by the Washington Department of Fish and Wildlife and the Northwest Indian Fisheries Commission (Appendix 1). The use of the PFC scenario in this analysis is intended to illustrate an environmental condition that is likely to result in robust fish populations in the Clackamas River but is still not equal to the historic potential of the river or to the Restored Reference scenario. PFC is not, however, necessarily advocated by any group as a feasible or target condition for the Clackamas River.

Reach and Area Structure

The assessment of the Clackamas was organized hierarchically. At the finest scale, information was developed for stream reaches that described the physical and biological environment of the stream. A total of 215 stream reaches were described throughout the Clackamas system. Reaches were defined by the technical team based on geomorphic and land use criteria. In some portions of the watershed, the team used reaches that had been defined for other stream surveys especially those conducted in the watershed by the Oregon Department of Fish and Game as part of their Aquatic Inventory Project (Moore and others 1997). Stream reaches for the EDT assessment also included 51 obstruction reaches. In EDT an obstruction such as culvert or dam is treated as a reach and hydrologically routed to other reaches. Each obstruction was rated by the technical committee as to its impediment to upstream or downstream movement of adult and juvenile fish.

Reaches were grouped into 14 geographic areas (Table 1) throughout the Clackamas watershed. An additional area (the Portland Area) added the Willamette River from the mouth of the Clackamas to the Columbia River. Geographic areas are groupings of stream reaches that are used to summarize the detailed stream reach results. Areas corresponded to major tributaries or sections of the mainstem. Smaller tributaries were grouped into separate groups (Table 1). Geographic areas were organized into three Sections corresponding to the major geomorphic divisions of the river. For this subbasin plan, information is presented at the level of the geographic areas in Table 1. However, reach level assessment of conditions for each life stage in each reach are available from the EDT assessment.

Table 1. Geographic structure of EDT assessment of the Clackamas River

Clackamas River EDT Structure

Section	Geographic Areas	Included streams
Lower Clackamas	Lower Clackamas	
	Lower Clack Tribs	
		Rock Cr.
		Richardson Cr.
		Foster Cr.
		Goose Cr.
		Cow Cr.
		Sieben Cr.
	Clear	
	Eagle	
	N. Fork Eagle	
	Deep	
		Tickle Cr.
PGE Dam complex (RM 23)		
Middle Clackamas	Middle Clackamas	
	Middle Clack Tribs	
		N. Fork Clackamas
		S. Fork Clackamas
		Sandstone Cr.
		Big Cr.
		Whale Cr.
		Cripple Cr.
		S. Fork Cripple Cr.
	Fish	
	Roaring	
Oak Grove Fork (RM 49)		
Upper Clackamas	Upper Clackamas	
	Upper Clackamas Tribs	
		Oak Grove Fork
		Tag Cr.
		Trout Cr.
		Pot Cr.
		Wolf Cr.
		Kansas Cr.
		Pinhead Cr.
		Last Cr.
		Lowe Cr.
		Rhododendron Cr.
		Fawn Cr.
		Hunter Cr.
		Cub Cr.
		Berry Cr.
	Collawash	
	Hot Springs	

Focal species and populations

Focal species for the assessment were chosen to characterize the environment and to capture habitat issues of concern to managers. We chose three anadromous salmonid focal species: coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*) and winter steelhead (*O. mykiss*). These species are native to the system although all are influenced by hatchery releases within the basin. We assume that robust, naturally spawning populations of these species are consistent with the normative condition for Clackamas and that constraints on their performance within the model reflect anthropogenic changes to the normative condition.

Populations were defined for each focal species (Table 2). The term population in EDT does not necessarily imply a genetic connotation. EDT populations are regions within a watershed composed of reaches that are delineated from other areas because of management interest (including possible genetic concerns) and to contrast different areas of the watershed. EDT begins life history trajectories for each population from reaches within the defined area. This group of trajectories may traverse several geographic areas (Table 1) over the course of the life history. For example, assessment results for the upper Clackamas coho population represent trajectories that began in reaches in the upper Clackamas and extended downstream through the middle and lower geographic areas in the Clackamas, the Willamette River and so on to complete a life history.

Table 2. Focal Species and EDT Populations in the Clackamas River

Species	Population
Chinook	Clackamas Fall Chinook Clackamas Spring Chinook
Coho	Upper Clackamas Coho Lower Clackamas Coho
Winter steelhead	Upper Clackamas Steelhead Lower Clackamas Steelhead

Chinook salmon in the Clackamas were divided into two populations on the basis of differences in adult and juvenile behavior and distribution within the system (Table 2). Fall chinook in the Clackamas spawn in the lower reaches of the mainstem and lower tributaries. They display an ocean type life history and outmigrate as juveniles in the spring and summer following emergence. Spring chinook potentially use the entire watershed including the entire length of the mainstem and many tributaries. Spring chinook display a stream type life history and remain as juveniles in the system for their first year and then outmigrate in their second spring.

Coho and steelhead were divided into two populations for each species using the PGE mainstem dams as the point of demarcation (Table 2). Both species are potentially present in almost all reaches of the Clackamas and tributaries. They have both been heavily influenced by management actions including hatchery programs that differ in the upper and lower sections of the river. For this reason and in order to contrast habitat conditions between the upper and lower portions of the river, we delineated the two populations for each species.

The two coho populations were based on the biological characteristics of the Clackamas Early Run Coho population. Managers have defined two coho populations in the Clackamas based on differences in return timing, spawning area and origin (Cramer and Cramer 1994). Native coho in the Clackamas River are the late run coho that spawn mainly in the lower reaches and tributaries below the PGE dams. The Lower Columbia River Technical Review Team (TRT) has designated this late returning life history as Type N coho (WLC-TRT 2003b). They enter the river late and spawn as late as February and March (Doug Cramer, personal communication). These fish are the remnants of the native coho in the Clackamas. Early run coho spawn throughout the river but originate from hatchery outplants. These fish spawn in late fall and are designated at Type S coho life history (WLC-TRT 2003b). While the late run coho probably originated from native Clackamas River coho, their late spawning time may have been skewed by intense harvest pressure in the past years (Doug Cramer, personal communication). Because our intent was to characterize habitat conditions and not explore, at this time, the implications of habitat effects on coho life histories, we used the early returning, Type N life history to characterize coho habitat in the Clackamas River.

Results of the Clackamas River Habitat Assessment

EDT assesses habitat in terms of four output parameters:

1. Biological capacity (quantity of habitat)
2. Biological productivity (quality of habitat)
3. Equilibrium abundance (quantity and quality of habitat)
4. Life history diversity (breadth of suitable habitat)

These output parameters assess habitat in regard to three assessment products:

1. Population Potential. This is the four output parameters for each of the six populations (Table 2) as a function of the habitat in the Clackamas River and the lower Willamette River.
2. Protection and Restoration priorities. Spatial differences between geographic areas within the Clackamas River were summarized as the Protection and Restoration value of each geographic area (Table 1 plus the Portland area) for each population. Protection priority is defined as the percent change in an EDT output parameter when the current values for all attributes in a geographic area are set to a highly <u>degraded</u> condition. Restoration priority is the percent change in an EDT output parameter when the current values for all attributes in a geographic area are set to a <u>restored</u> condition.

3. Attribute effects (limiting factors). The effect of individual attributes was assessed as the change in an EDT output parameter that occurred when the value for an individual attribute in a geographic area was set to its value in the restored condition. The results are summarized in "dot diagrams" in which the size of a dot is proportional to the change in productivity as a result of setting the EDT attribute to its restored value.

Habitat Assessment by Population

1. Lower Clackamas Populations

a. Lower Clackamas Coho

Population Description

The lower Clackamas River coho population was defined to spawn in the mainstem and all tributaries below River Mill Dam. Coho in the lower river are a combination of early and late run populations. For purposes of this habitat assessment, we have focused only on the early run portion. The life history of this population is based on Clackamas early run coho as described in Cramer and Cramer (1994). Early run coho in the Clackamas are a Type S population (WLC-TRT 2003b) because they enter the Clackamas River in August and spawn in October and November (Cramer and Cramer 1994) (Table 1). Natural spawners have been observed throughout the Clackamas basin below River Mill Dam (Cramer and Cramer 1994). Early run coho in the Clackamas are of hatchery origin and the returns to the river are predominantly of hatchery origin. Fish are released from Eagle Creek National Fish Hatchery and in other lower river tributaries.

Coho fry emerge from eggs around April (Table 3). They spend the next year in the tributaries and mainstem and outmigrate from the Clackamas the following spring after

Table 3. Generalized early returning (Type S) coho life history.

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upstream migration	0								■	■	■	■	■
Adult Holding	0								■	■	■	■	■
Spawning	0										■	■	■
Incubation-emergence	0	■	■	■	■						■	■	■
Juvenile rearing	1	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile outmigration	1			■	■	■	■	■					
Jack return	2								■	■	■	■	■
Adult return	3								■	■	■	■	■

one year in freshwater. Precocious males (jacks) return the next fall after less than one year in the ocean. The remaining adults spend one more year in the ocean to return to spawn as three-year old fish (Table 3).

Relation to ESU populations

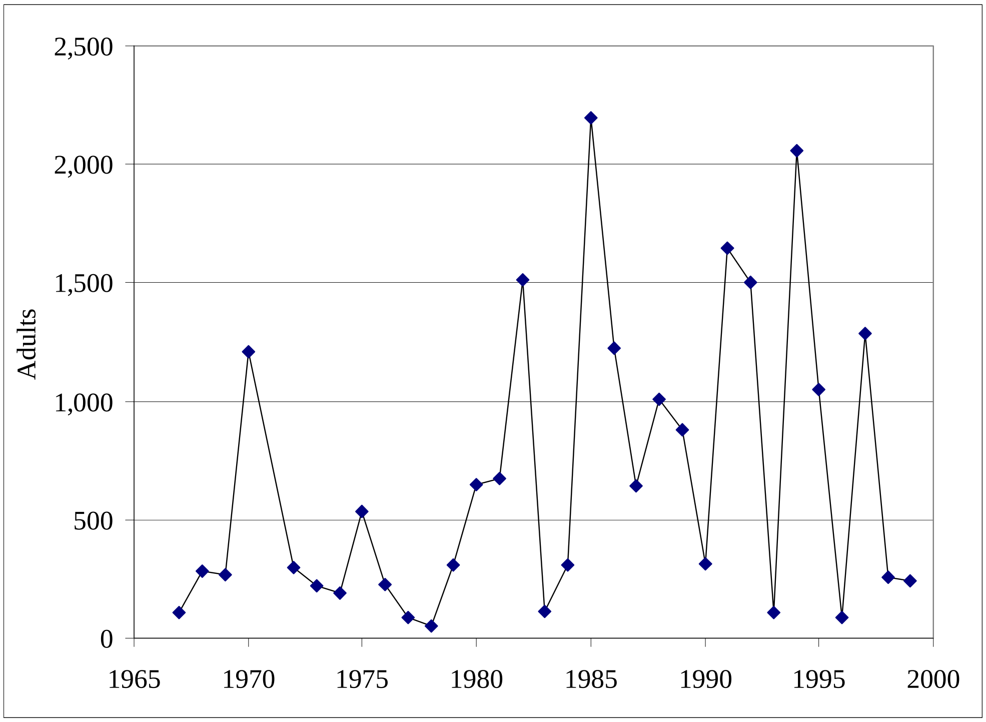
Coho is not a federally listed species in the Willamette or lower Columbia River. No Evolutionarily Significant Unit (ESU) is applicable to this population and the Lower Columbia Technical Recovery Team (TRT) has not designated populations. In their status review of lower Columbia River coho, NOAA Fisheries designated a single Clackamas River coho population (Myers and others 1998). The lower river population used in this assessment would be a part of the NOAA Fisheries population.

Present Status of coho in the lower Clackamas River

The most complete enumeration of returning salmon in the Clackamas River is the ladder count at North Fork Dam (Figure 3). While this count applies to coho that have passed the lower river reaches that apply to the Lower Clackamas coho population, the trend in early returning coho at North Fork provides an indication of the trend in abundance of this population. No clear trend in the count in Figure 1 is evident although counts since the mid-1970s have are generally greater than the count in the previous decade. This is likely the result of a decrease in commercial harvest rates over the period and precipitous drop in harvest in 1994 as a result of more restrictive harvest regulation. During the 1960s and 70s, harvest rates on were around 85-95 percent; after 1994, rates have been between 10 and 20 percent (WLC-TRT 2003b). Return of coho to at North Fork Dam since 1970 has averaged 720 adults and has varied widely from a low of a 54 to a high of 2,196.

For the lower Clackamas population specifically, the Oregon Department of Fish and Game (ODFW) estimated 2,402 natural spawners in the area below North Fork Dam in 2002. As noted above, early run coho are released from Eagle Creek Hatchery; ODFW estimated that 78 percent of the naturally spawning fish were of hatchery origin (WLC-TRT 2003b).

Figure 3. Count of adult early returning coho at North Fork Dam. (source: StreamNet)



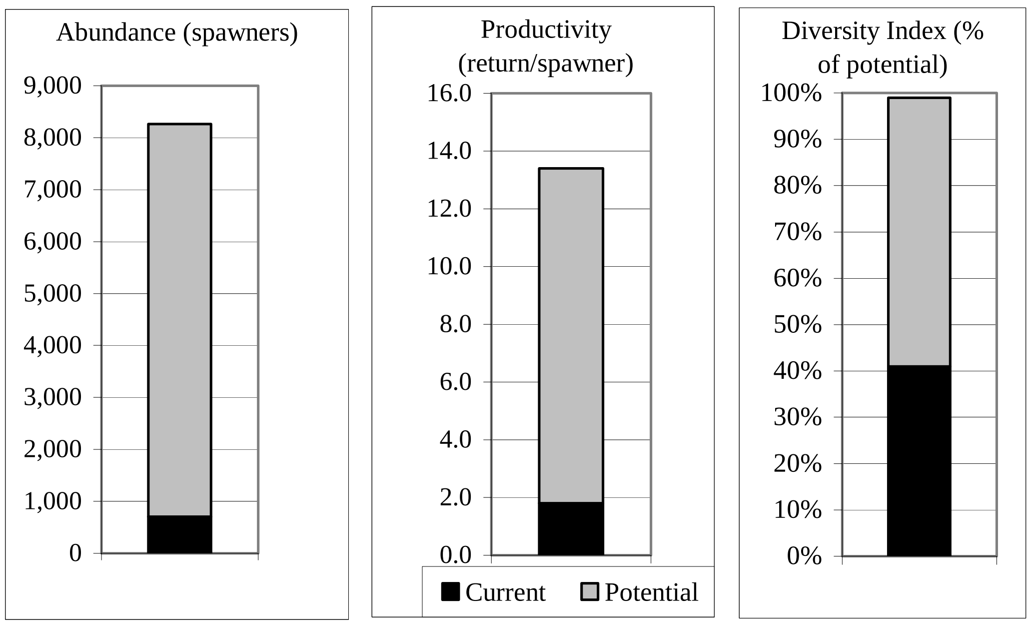
Habitat potential for coho in the lower Clackamas River

Habitat potential for coho in the lower Clackamas has been greatly reduced as a result of habitat modification relative to the EDT reference condition (Figure 4). Current abundance potential is 91 percent less than the potential under the reference condition. Productivity, a measure of habitat quality, is reduced by 86 percent. With harvest, current productivity is estimated to be only 1.6 (Figure 4). Given the expected ranges of natural environmental variation and events, it is questionable if natural production of coho is sustainable in the lower Clackamas River under the present habitat condition. In fact, much of the observed current natural production of coho in the lower Clackamas River is that occurs is of hatchery origin (WLC-TRT 2003b). Potential coho life history diversity, as a function of the breadth of suitable habitat conditions, has been reduced by more than half. This indicates a considerable narrowing of the area and time (within a year) for suitable coho habitat in the lower river.

Figure 4. EDT estimates of habitat potential in the lower Clackamas River for coho salmon. Numbers in graphs are without harvest.

Lower Clackamas Coho

Scenario	Diversity index	Productivity	Abundance
Current without harvest	41%	1.8	704
Current with harvest	38%	1.6	492
Reference potential	99%	13.4	8,262



May 11, 2004

Habitat priorities for coho in the lower Clackamas River

All reaches used by this population had low protection value (Figure 5) indicating that current conditions are degraded and that coho potential is greatly restricted in the current habitat condition. Clear Creek has the greatest current habitat potential (therefore greatest protection value) followed by Eagle and North Fork Eagle creeks. The pattern of protection priorities with respect to the Diversity Index also stressed the value of the tributary reaches. Lower Clackamas, Deep Creek and Clear Creek appear to support most of the present diversity of habitat and range of potential coho life histories (Figure 5).

Restoration of the lower mainstem area has the greatest potential to increase abundance and productivity of coho in the lower Clackamas population (Figure 5). Not only does this area have the potential to provide coho spawning habitat, but conditions in the lower mainstem also affect trajectories started from all upstream reaches. Restoration of conditions in Clear, Deep and North Fork Eagle creeks also has high potential to increase coho abundance and productivity.

The results in Figure 5 also indicate the close relationship between coho potential in the Clackamas and conditions in the lower Willamette. Restoration of the Portland reach had the fifth greatest impact on abundance of coho for all the reaches affecting this population and was on parr with most of the major lower river tributaries in terms of its impact on coho abundance in the lower Clackamas River. This primarily reflects the

Figure 5. Lower Clackamas River Coho Habitat Priorities. Protection priorities are determined by the change in a performance attribute with degradation while restoration priories are given by the change in performance with restoration.

Lower Clackamas River Coho

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection Rank	Restoration Rank
Portland	6	5
Lower Clackamas	5	1
Clear(CLA)	1	2
Deep(CLA)	4	3
Eagle(CLA)	2	4
North Fork Eagle(CLA)	3	5
Lower Clack Tribs	5	6

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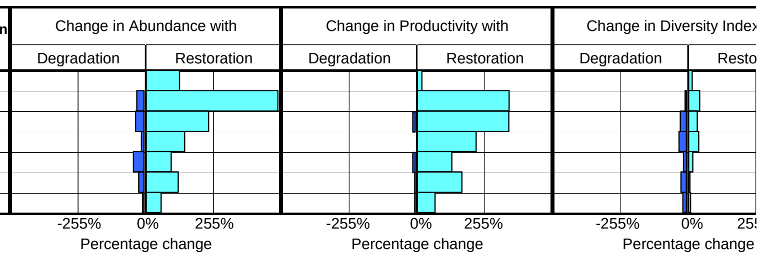


potentially large capacity of the lower Willamette for juvenile life stages that can add to the Clackamas populations.

Constraints on coho habitat potential in the lower Clackamas Rive

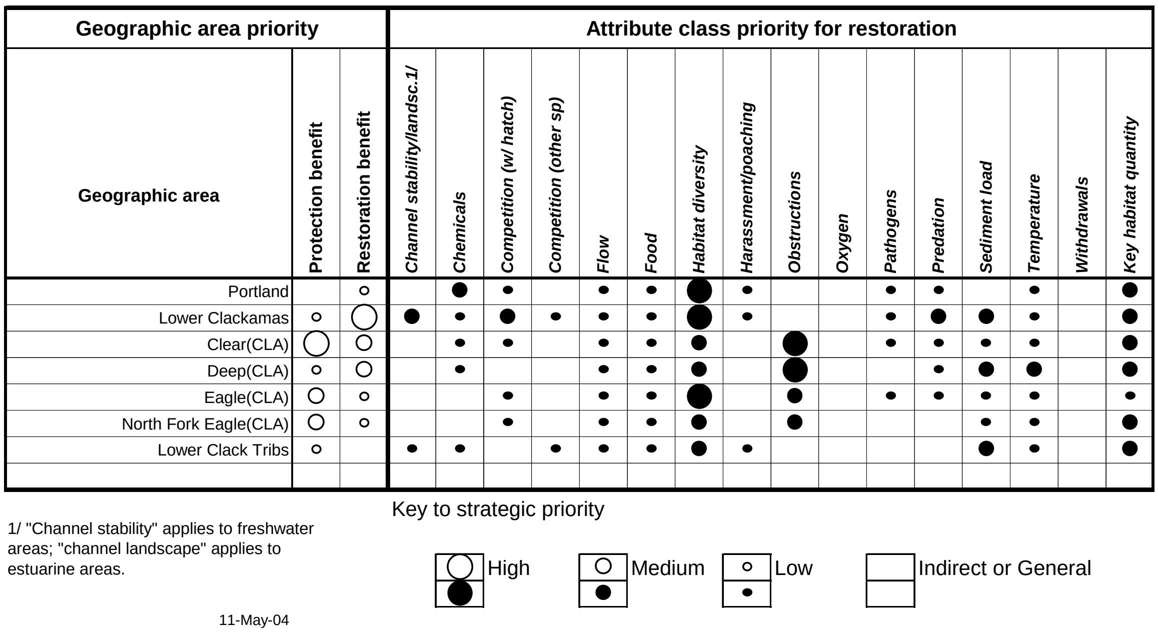
Figure 6 shows the relative contribution of individual habitat attributes to the restoration benefits in Figure 5. The quantity of habitat for coho in the lower Clackamas area has declined in every area (Key Habitat Quantity in Figure 6). This is the result of loss of off-channel areas (important overwintering habitat for juvenile coho) and the narrowing of the channel as a result of diking and encroachment of roads and other development along the stream bank.

The quality of habitat in the lower Clackamas has declined primarily as a result of reduced Habitat Diversity, increased Sediment and increased Temperature in summer (Figure 6). Habitat Diversity is a function of the decline in large woody debris and channel simplification due to artificial confinement of the channel behind dikes. Summer water temperature was a limitation on summer rearing of coho in all areas of the lower Clackamas especially in Deep Creek. Sediment was an important limiting factor in most areas in the lower Clackamas area but especially in Deep Creek and the lower Clackamas mainstem as well as other lower river tributaries.

Limiting factors for Clackamas coho in the lower Willamette (Portland) area were Chemicals, Habitat Diversity and loss of Key Habitat. The effect of Chemicals reflects pollutants from a variety of local and upriver sources. The loss of Habitat Diversity and Key Habitat a result of the overall channelization of the lower Willamette and the loss of wood and other structure and elimination of much of the shallow water habitat (McConnaha 2003).

Figure 6. Lower Clackamas River Coho Habitat Attribute Priorities. The change in productivity with restoration of an attribute is given by the size of the black dot, which is proportional to the overall restoration value given by the open circles to the left. A large black dot in an area with little overall restoration value (given by the size of the open circle) indicates little change in performance with restoration of the attribute.

Lower Clackamas River Coho
Protection and Restoration Strategic Priority Summary



Obstructions (culverts) were key limitations in the tributaries. Obstructions were particularly important in Deep Creek and Clear Creek. This assessment included nine culverts in Deep Creek and five culverts in Clear Creek. Obstructions were a lesser problem in Eagle Creek, including the North Fork of Eagle Creek. This system has three natural waterfalls that have been laddered and two artificial obstructions.

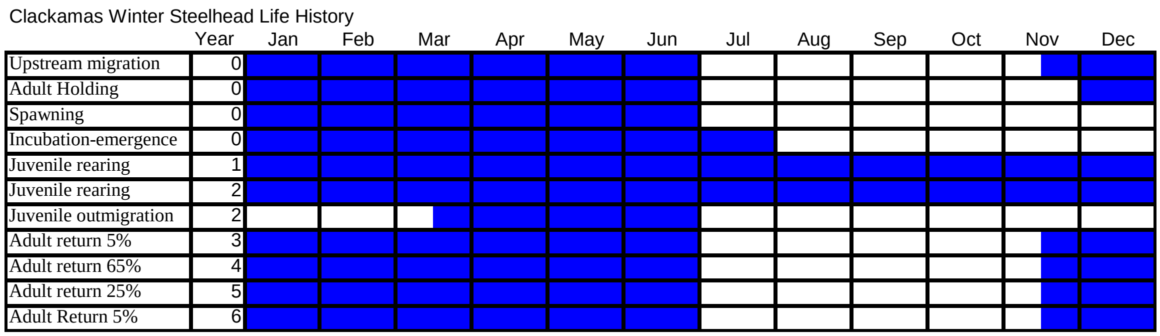
b. Lower Clackamas Steelhead

Population Description

The lower Clackamas River Steelhead population was defined for this assessment to potentially spawn in all accessible reaches below River Mill Dam. This population displays the winter run life history and is considered native to the Clackamas River (WLC-TRT 2003c).

Life history is based on the description of the Clackamas population provided by Hansen and others (2001). In contrast to coho, steelhead have a complex life history with a variety of patterns existing in the same populations. Figure 7 dpicts the general winter steelhead life history. Winter steelhead return to the Clackamas in late fall. Spawning occurs through the first quarter of the year mainly into the spring. Fry emerge in the spring and summer. Juvenile steelhead rear from one to four years in the Clackamas although the majority emigrate after a two year rearing period (Hansen and others 2001). Steelhead spend from one to four years in the ocean. In the Clackamas, most return after two years (as four year old fish) or three years (as five year old fish) in the ocean (Hansen and others 2001).

Figure 7. Generalized life history of winter steelhead in the Clackamas River



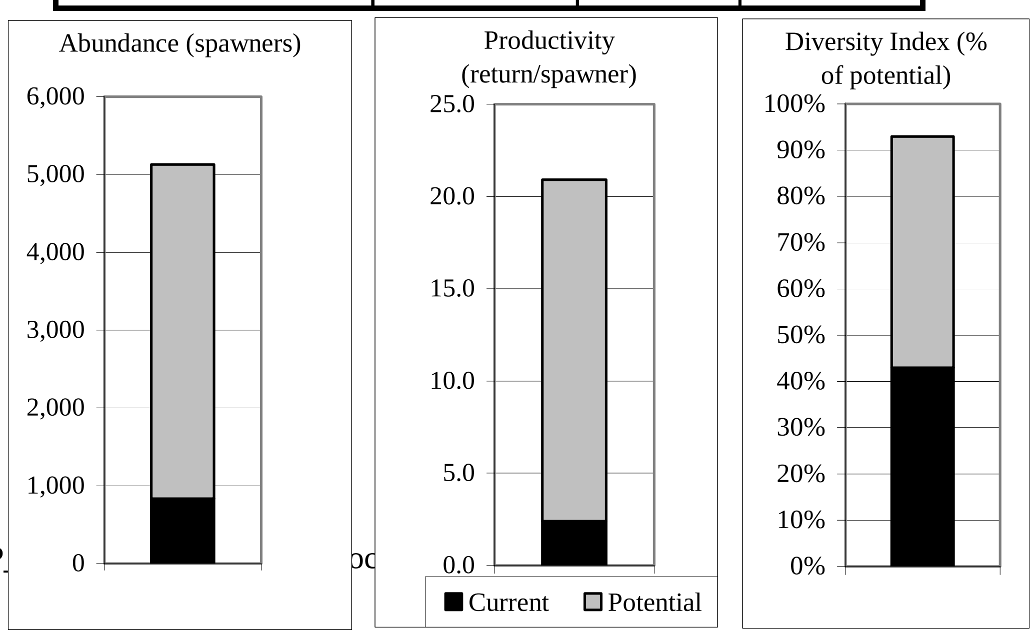
Relation to ESU populations

Clackamas River Winter Steelhead are part of the Lower Columbia River steelhead ESU (Busby and others 1996). Within this ESU the Technical Recovery Team (TRT) has recognized the Clackamas River winter steelhead population (WLC-TRT

Figure 9. EDT estimates of habitat potential in the lower Clackamas River for winter steelhead. Steelhead harvest outside the Willamette basin is considered to be zero.

Lower Clackamas Winter Steelhead

Scenario	Diversity index	Productivity	Abundance
Current without harvest	43%	2.4	833
Current with harvest	43%	2.4	833
Reference potential	93%	20.9	5,129



2003c). The lower Clackamas River steelhead population used in this analysis is the portion of the TRT population below River Mill Dam.

Present Status of winter steelhead in the lower Clackamas River

The return of winter steelhead to the Clackamas River has been in a general decline for the past several decades (Figure 8). Since 1970, the abundance at North Fork Dam as averaged 1,479 steelhead but has varied from 4,439 in 1970 to a low of 189 in 1998.

Habitat potential for winter steelhead in the Clackamas River

Current habitat potential for steelhead is significantly constrained in the lower Clackamas River relative to the EDT reference condition (Figure 9). Current abundance potential is 86 percent less than the potential under the reference condition. Productivity, a measure of habitat quality, is reduced by 88 percent. Potential steelhead life history diversity, as a function of the breadth of suitable habitat conditions in the lower Clackamas, has been reduced by 54 percent.

Figure 8. Abundance of winter steelhead at North Fork Dam. (data from StreamNet)

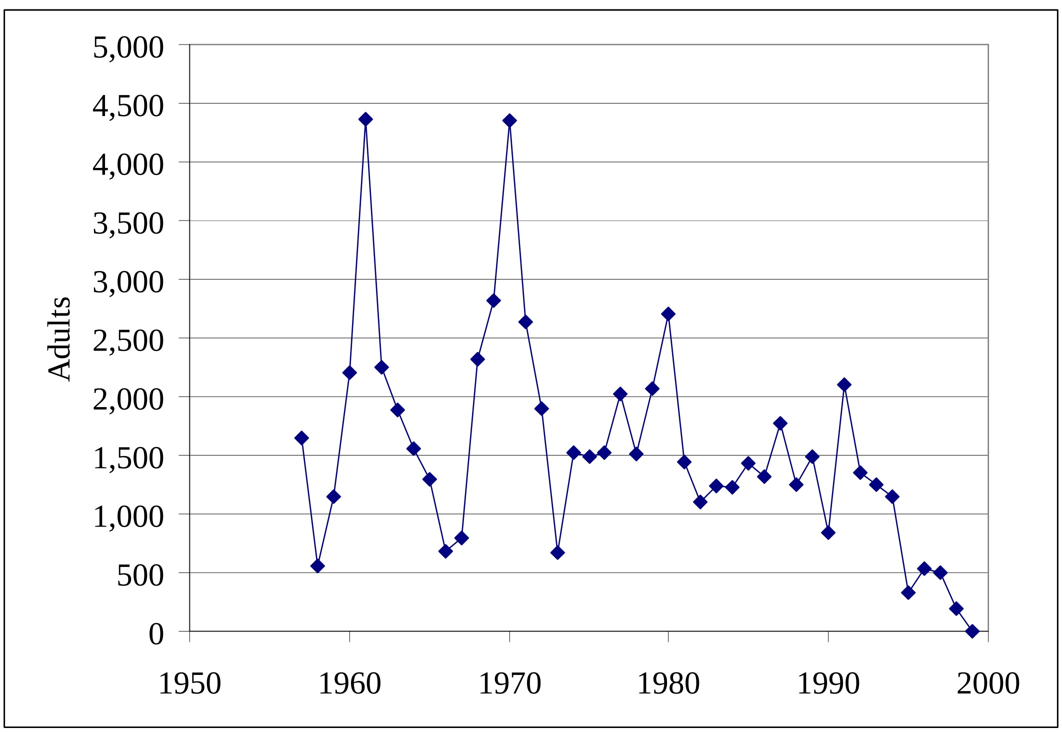
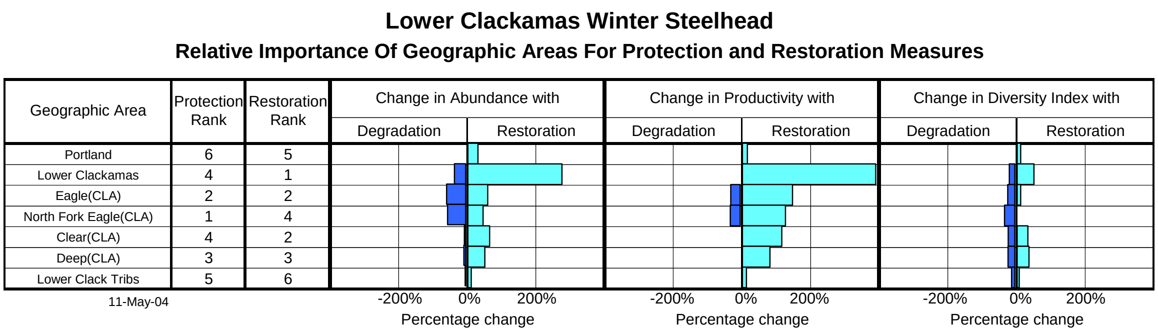


Figure 10. Lower Clackamas River Winter Steelhead Habitat Priorities. Protection priorities are determined by the change in a performance attribute with degradation while restoration priories are given by the change in performance with restoration.



Habitat priorities for steelhead in the lower Clackamas River

Most areas used by this population had relatively low protection values in the EDT assessment indicating that conditions are generally degraded in the lower Clackamas with respect to winter steelhead (Figure 10). The change to the current potential that occurred when conditions in each geographic area were degraded in the model indicates that the current abundance potential of steelhead in the lower Clackamas is heavily dependent on conditions in the lower Clackamas mainstem and the Eagle Creek watershed. The pattern of change in the Diversity Index with degradation (Figure 10) emphasizes the importance of conditions in the tributaries, especially Deep Creek, Eagle Creek and the North Fork Eagle Creek to maintain the current potential for life history diversity.

When conditions were set to the restored reference condition in each area, the greatest restoration value appeared in the Lower Clackamas mainstem reaches (Figure 10). Clackamas tributaries and the Portland reach of the Willamette had lesser, but collectively important restoration values for steelhead. Restoration of Clear Creek produced the greatest increase in steelhead life history diversity (Diversity Index) of any area in the lower Clackamas River.

Constraints on steelhead habitat potential in the lower Clackamas River

Temperature was a limiting factor for steelhead in every area of the lower Clackamas River (Figure 11). The primary Temperature impact on survival was on the egg incubation and early rearing stages during the spring and summer. Similar limitations were seen for juvenile coho (although not the egg incubation stage) in the lower Clackamas (Figure 6). Conditions in the lower Clackamas mainstem reaches, where overall restoration potential was the greatest, were limited by almost every survival factor, especially sediment and temperature (Figure 11). Factors associated with hatcheries, such as Competition with hatchery fish and Pathogens, were also significant for steelhead in the lower mainstem reaches. As with coho, obstructions in Deep Creek and especially Clear Creek were limiting. Clear Creek was also adversely affected by Pathogens because of the presence of whirling disease in a trout hatchery on the stream.

Figure 11. Lower Clackamas River Steelhead Habitat Attribute Priorities. The change in productivity with restoration of an attribute is given by the size of the black dot, which is proportional to the overall restoration value given by the open circles to the left. A large black dot in an area with little overall restoration value (given by the size of the open circle) indicates little change in performance with restoration of the attribute.

Lower Clackamas River Winter Steelhead
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	**Protection benefit**	**Restoration benefit**	*Channel stability/landsc.1/*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Portland	○ (Low)	○ (Low)		● (Medium)	● (Low)		● (Low)		● (Low)	● (Low)			● (Low)	● (Low)				● (Low)
Lower Clackamas	○ (Medium)	○ (High)	● (Low)	● (Low)	● (Medium)	● (Low)	● (Low)	● (Low)	● (Low)	● (Low)			● (Medium)	● (Medium)	● (Medium)	● (Medium)		● (Low)
Eagle(CLA)	○ (High)	○ (Medium)			● (Low)		● (Low)		● (Low)		● (Medium)		● (Low)	● (Low)	● (Low)	● (Medium)		● (Low)
North Fork Eagle(CLA)	○ (High)	○ (Low)			● (Low)		● (Low)				● (Medium)		● (Low)	● (Low)	● (Medium)	● (Low)		● (Medium)
Clear(CLA)	○ (Medium)	○ (Medium)		● (Low)			● (Low)	● (Low)	● (Low)		● (High)		● (Medium)	● (Low)	● (Low)	● (Medium)		● (Low)
Deep(CLA)	○ (Medium)	○ (Medium)		● (Low)			● (Medium)		● (Low)		● (High)		● (Low)	● (Low)	● (Medium)	● (Medium)		● (Medium)
Lower Clack Tribs	○ (Low)			● (Low)			● (Medium)	● (Low)	● (Low)	● (Low)			● (Low)	● (Low)	● (Medium)	● (Medium)		● (Medium)

Key to strategic priority

1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

○ / ● High	○ / ● Medium	○ / ● Low	Indirect or General

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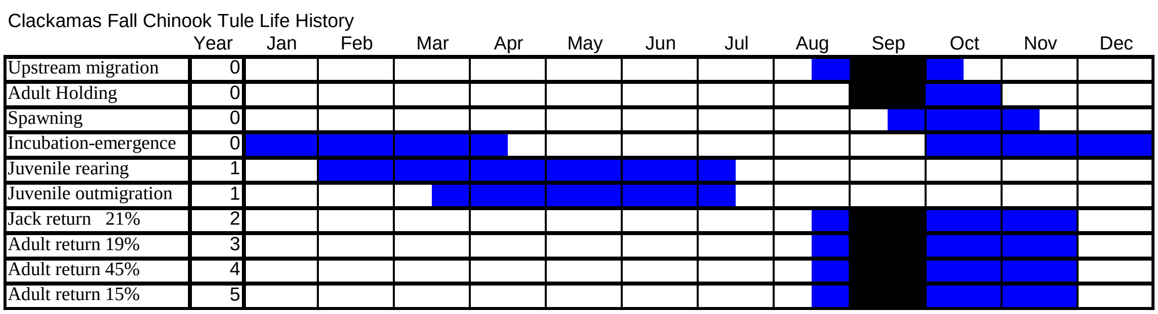
c. Clackamas River Fall Chinook

Population Description

Fall chinook in the Clackamas River are largely confined to the mainstem below River Mill Dam and the lower reaches of the major tributaries in the lower river (Doug Cramer, PGE, personal communication). Historically they probably extended up through the Middle Clackamas reaches. Fall chinook are native to the Clackamas River, however, the population was extirpated in the mid-1930s due to poor water quality in the lower Willamette. The run was re-established from lower Columbia River hatchery stocks; however, stocking ceased in the early 1980s and the run is now supported by natural production (WLC-TRT 2003a).

The population is part of the lower Columbia River fall chinook group (Howell and others 1985) and is considered a tule life history. Columbia River tule fall chinook are an important component of commercial harvest off Oregon, Washington and southern British Columbia. Fall chinook are released in large numbers from several lower Columbia River hatcheries to support these fisheries (Mobrand Biometrics 2003) although fall chinook in the Clackamas are natural spawners. In contrast to other salmonid species considered in this assessment, fall chinook spend a relatively short time in freshwater (Figure 12). Adults enter the river in August with peak returns in September. Spawning commences soon after entry to the Clackamas in September and October. Chinook fry emerge in the spring. Juvenile fall chinook spend relatively little time in the Clackamas and begin moving downstream toward the estuary during the

Figure 12. Generalized life history of Clackamas River Tule Fall Chinook (after Howell and others (1985)).



spring and summer.

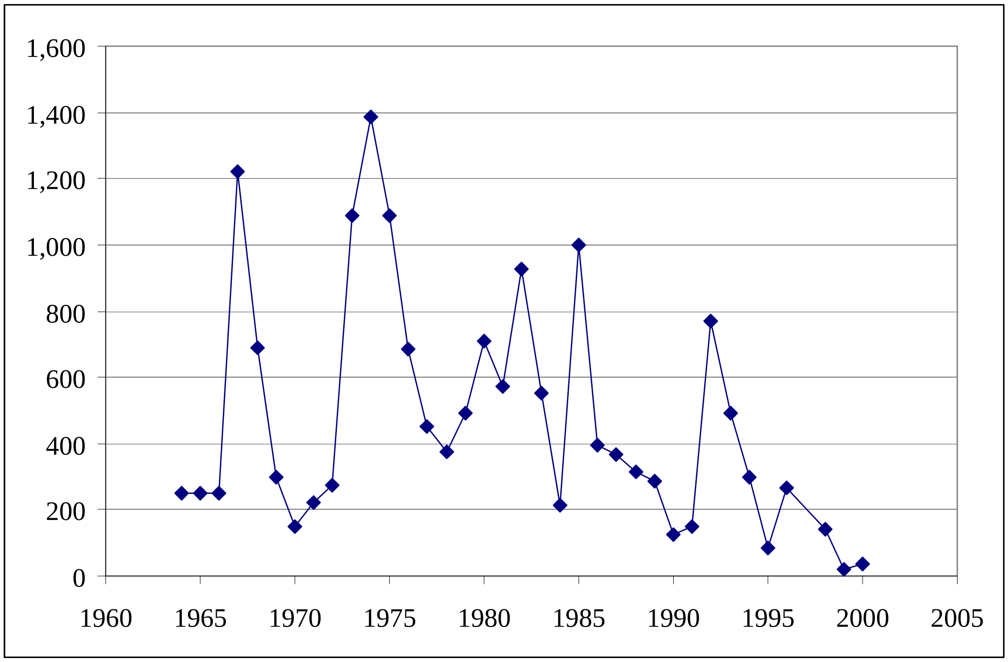
Relation to ESU populations

Clackamas River fall chinook are included in the Lower Columbia chinook ESU (Myers and others 1998).

Present status of fall chinook in the lower Clackamas River

Fall chinook are counted by ODFW in the lower Clackamas River (Figure 13). Since the mid-1960's, returns to the Clackamas River have generally declined. The estimated return has varied widely from a high of 1,385 fish in 1974 to a low of 20 fish in 1999. Returns over the period averaged 469 fish.

Figure 13. Estimated abundance of Clackamas River fall chinook below River Mill Dam. (data from StreamNet)



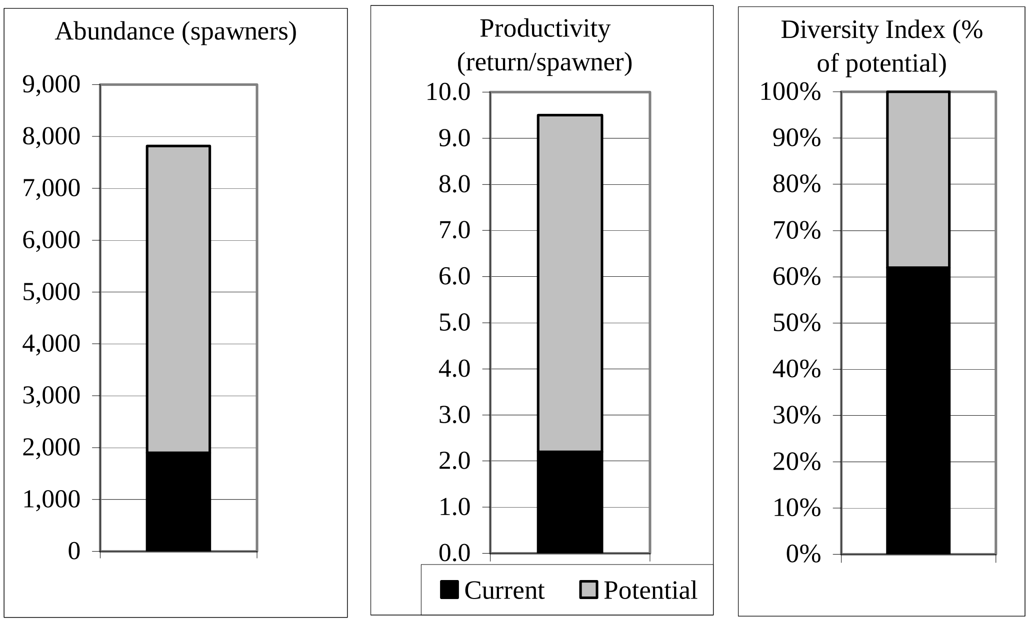
Habitat potential for fall chinook in the lower Clackamas River

Current habitat potential of the lower Clackamas River for fall chinook (without harvest) is about 24 percent of the potential under the restored reference condition (Figure 14). Harvest further reduces the estimated abundance potential of the habitat to 6 percent of the reference condition. Current estimated productivity with harvest is only 1.3—barely above replacement. With normal environmental variation and events, it is unlikely that the current habitat can support a sustainable natural population of fall chinook in the Clackamas River. The life history diversity (Diversity Index) that could be expected from the current habitat breadth is about 62 percent of that expected under the reference condition. The current restriction on the Diversity Index is less that was seen for other lower Clackamas salmon populations. This is because fall chinook mainly use the mainstem and do not ascend far up the tributaries. The mainstem is a relatively uniform habitat unit that would be expected to produce a relatively uniform life history response compared to the varied solutions used by other species to exploit tributary and mainstem habitats. Although the habitat quality and quantity of the mainstem has declined, reducing productivity and capacity, the range of potential life histories has declined to a lesser degree.

Figure 14. EDT estimates of habitat potential in the lower Clackamas River for fall chinook. Numbers in graphs are without harvest.

Lower Clackamas Fall Chinook

Scenario	Diversity index	Productivity	Abundance
Current without harvest	62%	2.2	1,904
Current with harvest	49%	1.3	466
Reference potential	100%	9.5	7,816



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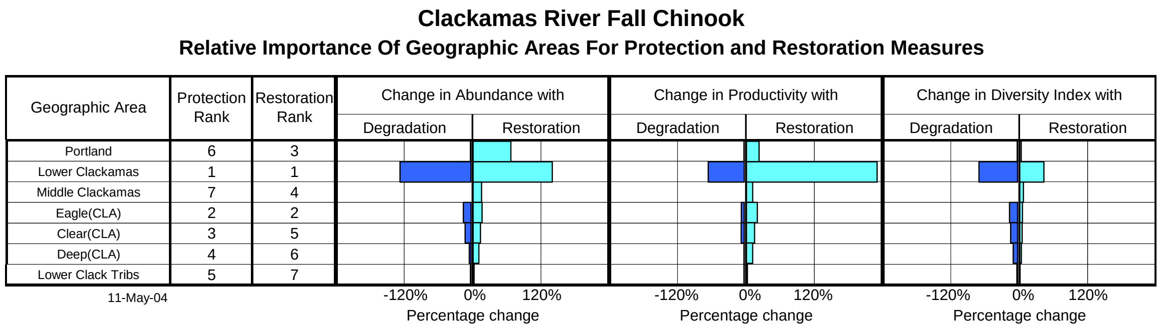
Habitat priorities for fall chinook in the lower Clackamas River

Because fall chinook typically spawn in larger tributaries and rivers, it is not surprising that the Lower Clackamas area (lower mainstem reaches) had almost all of the protection value under current conditions (Figure 15); degradation of conditions in the lower mainstem in the model eliminated almost all fall chinook. The lower reaches of the tributaries added some value for the Diversity Index.

Restoration value was similar with almost all of the restoration value being in the lower mainstem area (Figure 15). The Portland area of the Willamette provided the second highest restoration value for Clackamas fall chinook. Under a restored condition, the lower Willamette adds considerable rearing habitat that would be used by juvenile fall chinook as they move toward the estuary.

Figure 15. Clackamas River Fall Chinook Habitat Priorities. Protection priorities are determined by the change in a performance attribute with degradation while restoration priories are given by the change in performance with restoration.



Constraints on fall chinook habitat potential in the lower Clackamas River

The major factor limiting fall chinook production in the Clackamas River is water temperature during the late summer and fall (Figure 16). Water temperature in the lower Clackamas during September, when fall chinook spawn was rated high enough to preclude successful spawning of fall chinook until temperatures moderated in October. Sediment, Habitat Diversity and Channel Stability were also rated as important limiting factors for fall chinook in the lower mainstem.

Figure 16. Clackamas River Fall Chinook Habitat Attribute Effects. The change in productivity with restoration of an attribute is given by the size of the black dot, which is proportional to the overall restoration value given by the open circles to the left. A large black dot in an area with little overall restoration value (given by the size of the open circle) indicates little change in performance with restoration of the attribute.

Clackamas River Fall Chinook
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability/landsc.1/	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Portland		Medium		Low	Low		Low	Low	Medium	Low			Low	Low		Low		Medium
Lower Clackamas	High	High	Medium	Low			Low	Low	Low	Low			Low	Medium	Medium	High		Low
Middle Clackamas		Low					Low	Low	Medium	Low			Low	Low	Medium			High
Eagle(CLA)	Medium	Medium					Low							Low	Medium	High		
Clear(CLA)	Medium	Low		Low			Low	Low		Low				Low	Low	High		Low
Deep(CLA)	Low			Medium			Low	Low							Medium	High		Low
Lower Clack Tribs	Low			Medium			Low	Low							Medium	High		Medium

1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

Key to strategic priority: High; Medium; Low; Indirect or General

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2. Upper Clackamas Populations

Upper Clackamas River Coho

Population Description

Upper Clackamas Coho were defined to potentially spawn in the mainstem and tributaries above North Fork Dam. Naturally spawning coho in the upper Clackamas River are almost entirely composed of the early returning life history (Cramer and Cramer 1994). The native late returning segment does not appear to do well in the upper basin perhaps because water temperatures are too low in the upper basin by the time the later fish arrive (Cramer and Cramer 1994). Population characteristics of the early returning coho were described in Section 1.a. above (Table 3) and in Cramer and Cramer (1994).

Relation to ESU populations

Coho is not a federally listed species in the Willamette or lower Columbia River. No Evolutionarily Significant Unit (ESU) is applicable to this population and the Lower Columbia Technical Recovery Team (TRT) has not designated populations. In their status review of lower Columbia River coho, NOAA Fisheries designated a single Clackamas River coho population (Myers and others 1998). The upper river population used in this assessment would be a part of the NOAA Fisheries population.

Present status of coho in the upper Clackamas River

Figure 3 shows the count of adult coho at North Fork Dam as an index of population trend. Although counts have varied widely over the period, the trend is generally positive, probably reflecting the large decrease in commercial harvest on coho in 1994 (WLC-TRT 2003b). In contrast to the lower Clackamas population that receives considerable supplementation from hatcheries, the ODFW estimated in 2002 that the count of coho at North Fork Dam was only 12 percent hatchery fish (WLC-TRT 2003b).

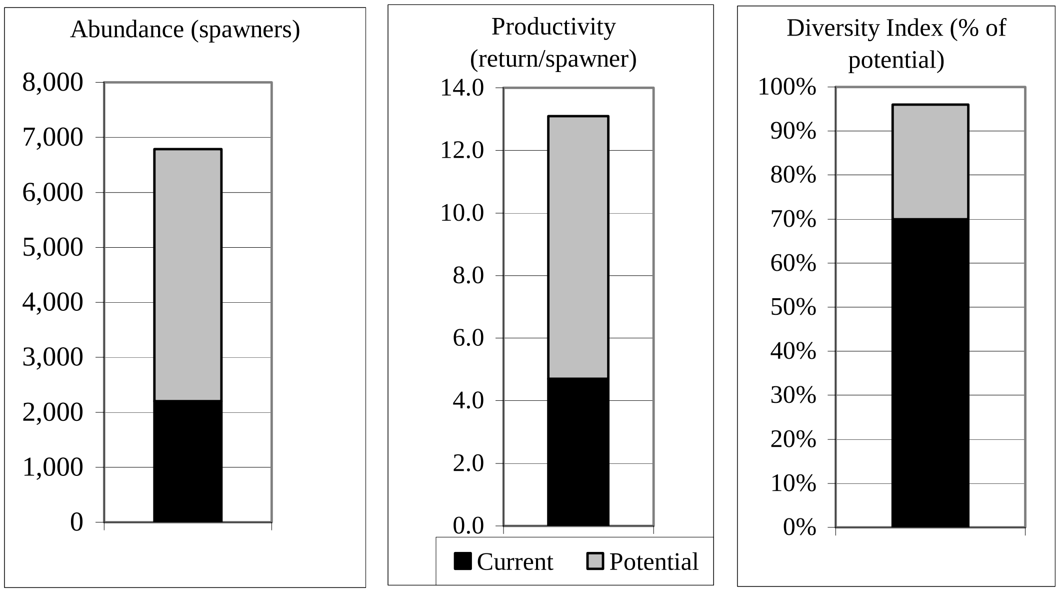
Habitat potential for coho in the upper Clackamas River

Although significantly habitat constraints exist for coho in the upper Clackamas River, habitat is less degraded than it is in the lower river. Current abundance potential of upriver habitat is 32 percent of the reference (Figure 17) compared to about 8.5 percent for the lower river population (Figure 4). Productivity of coho in the upper basin is about 4.0 compared to 1.3 in the lower river; the upper basin likely has the potential to sustain a naturally producing population in contrast to the lower basin. Potential life history diversity (Diversity Index) for the coho in the upper basin is 73 percent compared to 41 percent for coho in the lower river. This indicates that the general structure of habitat in the upper basin, in terms of times and areas of suitable habitat conditions, remains relatively intact even though the quality and quantity of habitat is reduced compared to the reference condition.

Figure 17. EDT estimates of habitat potential in the upper Clackamas River for coho salmon. Numbers in graphs are without harvest.

Upper Clackamas Coho

Scenario	Diversity index	Productivity	Abundance
Current without harvest	70%	4.7	2,202
Current with harvest	68%	4.0	1,829
Reference potential	96%	13.1	6,785



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Habitat priorities for coho in the upper Clackamas River

Current habitat potential for coho in the upper Clackamas area is concentrated in the Upper Clackamas mainstem (above Oak Grove Fork), Middle Clackamas mainstem (Oak Grove Fork to North Fork Dam) and Collowash River areas (Figure 18). The Upper Clackamas area includes the Big Bottom area that is generally considered to be the most intact habitat in the Clackamas River (USFS 1995). The present life history diversity (Diversity Index) reflects the diversity of habitats areas in the upper Clackamas afforded by mainstem and tributaries, especially the Collowash and Hot Springs tributaries and the collection of smaller tributaries in the upper basin (Upper Clack Tributaries). As with the other populations discussed above, the current value of the tributary areas is less in regard to increasing overall abundance than it is in protecting the potential life history diversity afforded by a diversity of areas and times with suitable habitat conditions.

The greatest restoration value for coho in the upper Clackamas lies in the Middle Clackamas area (Figure 18). This is largely a function of the PGE dam complex and reservoir and illustrates the constraints on production in the upper basin as a result of the shift from riverine habitat in the reference to the dams and reservoir in the current condition. The important restoration value of the lower Clackamas arises because all coho life history trajectories generated from the upper basin must pass through the lower river as adults and juveniles; restoration of conditions in these lower reaches provided considerable benefit to the upriver population.

The Portland area of the Willamette had significant restoration value for upper Clackamas coho again emphasizing the close relationship between the Clackamas and the lower Willamette (Figure 18). Restoration of water quality in the lower Willamette improved survival for all populations; restoration of shallow water habitat in the Portland area greatly increased the rearing capacity for coho originating in both the lower and upper portions of the Clackamas.

Figure 18. Upper Clackamas River Coho Habitat Priorities. Protection priorities are determined by the change in a performance attribute with degradation while restoration priories are given by the change in performance with restoration.

Upper Clackamas River Coho

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection Rank	Restoration Rank
Portland	9	4
Lower Clackamas	6	4
Middle Clackamas	3	2
Roaring(CLA)	8	8
Fish(CLA)	7	6
Middle Clack Tribs	5	9
Upper Clackamas	1	3
Collowash(CLA)	4	5
Hot Springs Fork(CLA)	5	7
Upper Clack Tribs	2	1

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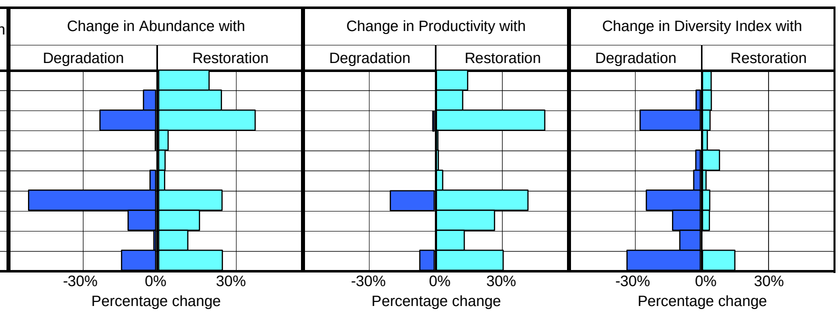

Constraints on coho habitat potential in the upper Clackamas River

The primary factors limiting coho in the upper Clackamas reaches are Habitat Diversity and loss of Key Habitat Quantity (Figure 19). The loss of Habitat Diversity is almost entirely a function of the decline in large wood in the stream and river due to changes in riparian forests and overt removal. The loss of habitat quantity reflects a general narrowing of the channel (therefore loss of habitat area). In the upper basin this generally is due to roads that follow the stream course and impinge on the channel dynamics.

Habitat limitations in the lower Clackamas mainstem and the lower Willamette (Portland) area for upper river coho were similar to the limitations seen for lower river coho (Figure 19). Decline in Habitat Diversity, high summer water Temperature and decline in Key Habitat Quantity were key factors in the lower Clackamas. In the Willamette, Chemicals (pollutants), Habitat Diversity and Key Habitat Quantity limited production of upper river coho.

Obstructions (culverts) are key factors in the upper basin (Figure 19). Within this analysis, the smaller tributaries to the Clackamass (Upper Clack Tribs) had eleven culverts with varying degrees of passage. Obstructions were also important in the Collowash River and Hot Springs Fork. In the Middle Clackamas mainstem, obstructions showed up as a problem as a result of the passage mortality at the three PGE dams.

Figure 19. Upper Clackamas River Coho Habitat attribute effects. The change in productivity with restoration of an attribute is given by the size of the black dot, which is proportional to the overall restoration value given by the open circles to the left. A large black dot in an area with little overall restoration value (given by the size of the open circle) indicates little change in performance with restoration of the attribute.

Upper Clackamas River Coho
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability/landsc.1/*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Portland		∘		●					●	•			•	•				●
Lower Clackamas		∘			•			•	●				•	●		•		●
Middle Clackamas	○	○			•		•	•	●	•	●			•	●			•
Roaring(CLA)			•				•	•	⬤						●			●
Fish(CLA)			•				•	•	⬤						●	•		•
Middle Clack Tribs	∘						•		●						●			•
Upper Clackamas	◯	○					•		●	•					•			•
Collowash(CLA)	∘	∘							⬤		●				●			•
Hot Springs Fork(CLA)	∘						•		●		●				●			●
Upper Clack Tribs	○	◯					•		●		⬤				●			●

1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

Key to strategic priority

◯ / ⬤ High; ○ / ● Medium; ∘ / • Low; (blank) Indirect or General

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Upper Clackamas River Winter Steelhead

Population Description

The upper Clackamas River Steelhead population was defined for this assessment to potentially spawn in all accessible reaches above North Fork Dam and is otherwise identical to the lower Clackamas steelhead population. This population displays the winter run life history and is considered native to the Clackamas River (WLC-TRT 2003c). The life history is based on the description of the Clackamas population provided by Hansen and others (2001). Life history information is summarized in Section 1.b. and Figure 7.

Relation to ESU populations

Clackamas River Winter Steelhead are part of the Lower Columbia River steelhead ESU (Busby and others 1996). Within this ESU the Technical Recovery Team (TRT) has recognized the Clackamas River winter steelhead population (WLC-TRT

2003c). The upper Clackamas River steelhead population used in this assessment is the portion of the TRT population above North Fork Dam.

Present Status of winter steelhead in the lower Clackamas River

Figure 8 shows the count of steelhead at North Fork Dam as an index of population trend. Counts have varied widely but, overall, the return of steelhead to the upper basin shows a declining trend over the period. ODFW estimated that about 52 percent of the recent steelhead returns at North Fork Dam were of "wild" origin (WLC-TRT 2003b).

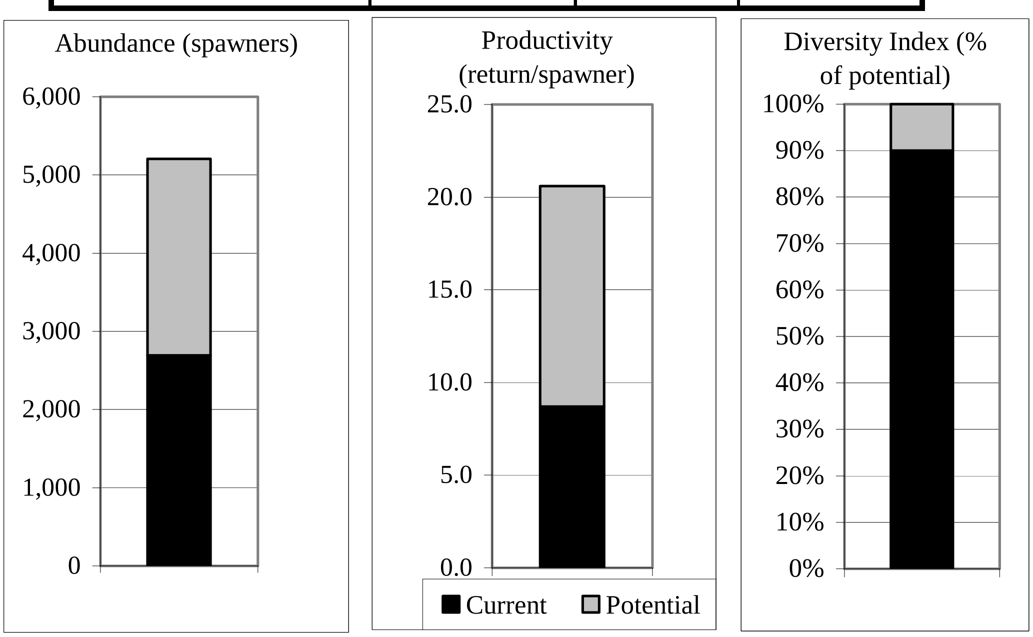
Habitat potential for winter steelhead in the upper Clackamas River

Population potential of winter steelhead in the upper Clackamas River is limited at the present time by habitat constraints (Figure 20). Abundance potential of steelhead in the upper Clackamas River under the current habitat condition is about 52 percent of the potential under the reference habitat condition. However, this is better than the condition of habitat in the lower basin where current potential for steelhead is only 16

Figure 20. EDT estimates of habitat potential in the upper Clackamas River for winter steelhead. Steelhead harvest outside the Willamette basin is considered to be zero.

Upper Clackamas Winter Steelhead

Scenario	Diversity index	Productivity	Abundance
Current without harvest	90%	8.7	2,693
Current with harvest	90%	8.7	2,693
Reference potential	100%	20.6	5,208



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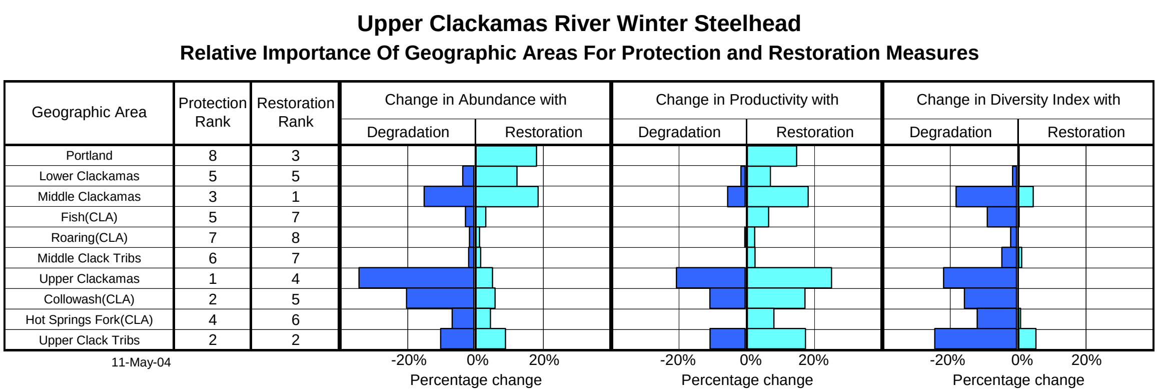
percent of the potential under the reference condition (Figure 9). Potential productivity of steelhead under the present habitat configuration is a relatively healthy value of 8.7 returns/spawner. Although the habitat quality and quantity has declined and reduced the abundance potential for steelhead, the structure of the habitat (the places and times within a year where suitable conditions exist for steelhead) appears relatively intact in the upper basin. Winter steelhead in the upper Clackamas had the highest Diversity Index of any population in this assessment; current diversity was only 10 percent less than the diversity under the reference condition (Figure 20).

Habitat priorities for steelhead in the upper Clackamas River

The pattern of protection priorities in Figure 21 indicate that much of the current potential for steelhead in the upper Clackamas River is in the upper mainstem, middle

Figure 21. Upper Clackamas River Winter Steelhead Habitat Priorities. Protection priorities are determined by the change in a performance attribute with degradation while restoration priories are given by the change in performance with restoration.



mainstem and the Collowash River. As with other populations considered so far, the existing breadth of suitable habitat conditions indexed by the Diversity Index depends greatly on tributaries especially the collection of Upper Clack Tribs (Figure 21).

Restoration priorities for steelhead in the upper Clackamas (Figure 21) indicate that abundance is currently limited largely by conditions in the middle Clackamas mainstem, the lower Clackamas mainstem and the lower Willamette (Portland). The upper Clackamas mainstem and all tributaries had relatively low restoration values indicting that conditions are generally good for steelhead in these areas. In the middle Clackamas, which had the highest restoration value, the high restoration priority reflects the effect of the PGE dams and reservoirs. Restoration of the lower Willamette added considerable capacity to all populations in the Clackamas including upper river steelhead. The restoration priority for the lower Clackamas is because all steelhead trajectories generated from the upper basin had to pass through the lower Clackamas during the juvenile and adult life stages.

Figure 22. Upper Clackamas River Steelhead Habitat attribute effects. The change in productivity with restoration of an attribute is given by the size of the black dot, which is proportional to the overall restoration value given by the open circles to the left. A large black dot in an area with little overall restoration value (given by the size of the open circle) indicates little change in performance with restoration of the attribute.

Upper Clackamas River Winter Steelhead
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability/landsc.1/*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Portland		○ Medium		● Medium					● Low	● Low				● Low				● Low
Lower Clackamas	○ Low	○ Low			● Low								● Low	● Medium				● Low
Middle Clackamas	○ Medium	○ High						● Low	● Medium	● Low	● Low			● Low	● Medium			● Low
Fish(CLA)	○ Low						● Low		● Low					● Low	● Medium	● Low		● Low
Roaring(CLA)							● Low		● Low						● Medium			● Medium
Middle Clack Tribs							● Low		● Low		● High				● Medium			● Low
Upper Clackamas	○ High	○ Low							● Low	● Low				● Low	● Medium			● Low
Collowash(CLA)	○ Medium	○ Low									● Medium				● Medium			● Low
Hot Springs Fork(CLA)	○ Low						● Low		● Low		● High				● Medium			● Medium
Upper Clack Tribs	○ Medium	○ Medium							● Low		● High			● Low	● Medium			● Medium

1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

Key to strategic priority

○ / ● (large)	High
○ / ● (medium)	Medium
○ / ● (small)	Low
(empty)	Indirect or General

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Constraints on steelhead habitat potential in the upper Clackamas River

Overall, habitat conditions for steelhead in the upper Clackamas appear to be good. The major constraint in the upper mainstem area in this assessment was some loss of habitat quantity, probably as a result of a narrowing of the channel due to road building next to the channel, and a small loss of habitat diversity resulting from a decline in large wood (Figure 22. These problems were present in the tributaries as well, however, the biggest limitation in the upper basin tributaries was obstructions (Figure 22). Although these same obstructions were problems for coho, they were an even greater impediment to the movement of steelhead into potentially productive habitat.

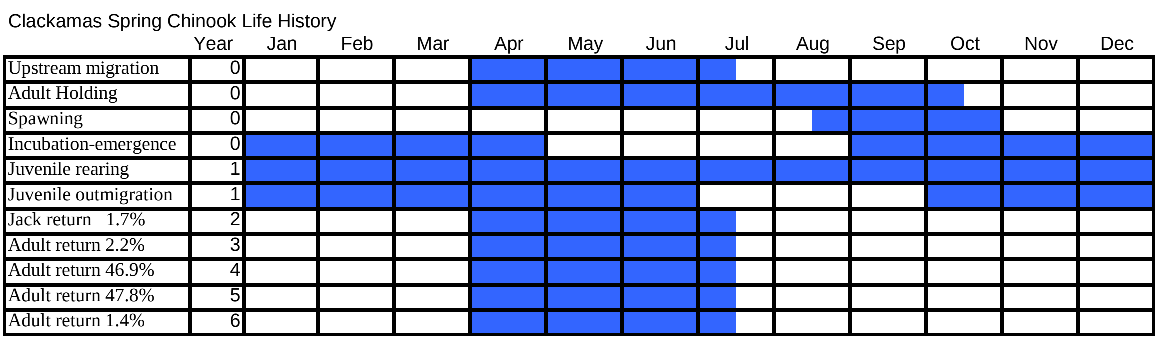
Most of the habitat constraints on steelhead in the upper basin occur downstream in the middle and lower mainstem reaches and the lower Willamette. The problems in these areas have been discussed previously in connection with other populations. The major constraint in the middle Clackamas have to do with the PGE dams and reservoirs and the loss of spawning habitat and passage mortality at the dams. In the lower Clackamas, channel straightening, confinement and loss of habitat complexity limit steelhead and coho. Constraints in the lower Willamette include Chemicals (pollutants) and loss of shallow water habitat.

Clackamas River Spring Chinook

Population Description

The Clackamas River Spring Chinook population was defined to spawn in reaches throughout the Clackamas basin. This spring chinook population was modeled with a stream type life history meaning that after emergence in their first spring, juveniles spend and entire year in freshwater and outmigrate from the Clackamas in their second spring. Life history characteristics for this assessment were based on Howell and others (Howell and others 1985). Adults enter in the early spring and hold in deep pools over the summer before moving to spawning areas in the fall (Figure 23). After emergence the next spring, the juveniles rear for a year generally tributaries and margins of the mainstem. They have a pronounced spring outmigration as one year olds. Most adults return to the Clackamas after three or four years in the ocean (Figure 23).

Figure 23. Generalized spring chinook life history in the Clackamas River.



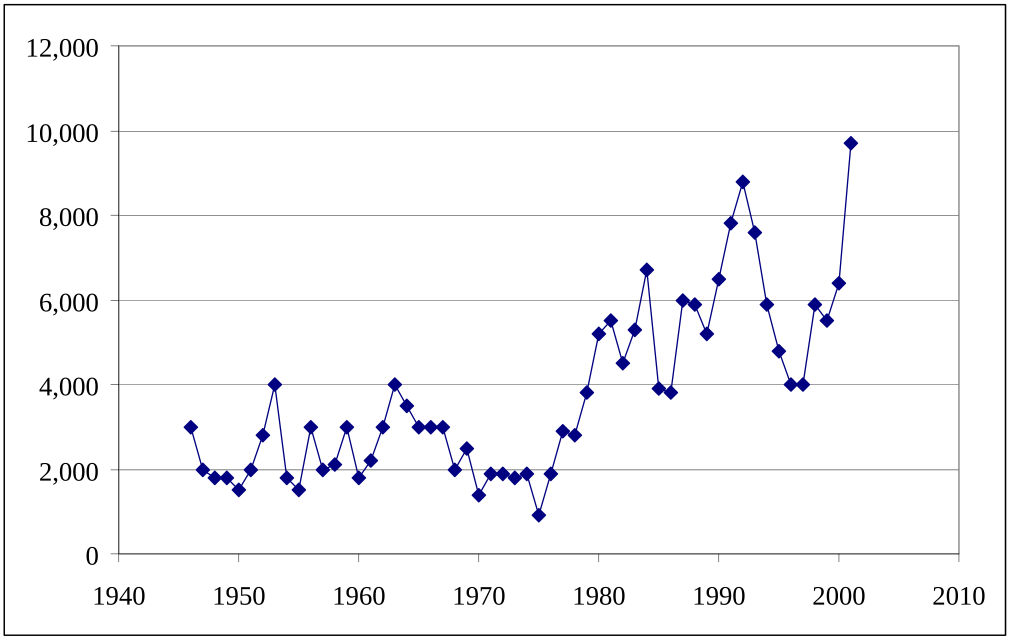
Relation to ESU populations

Clackamas spring chinook are part of the Upper Willamette River spring chinook ESU (Myers and others 1998).

Present status of spring chinook in the Clackamas River

Estimated return of spring chinook to the Clackamas River is shown in Figure 24. Returns of spring chinook have increased in the Clackamas River since the mid-1970's. Since that time, returns have ranged from to a low of 900 in 1975 to a high of 9,700 in 2001. Return of spring chinook to the Clackamas River since the mid-1970's has averaged 4,691 fish.

Figure 24. Estimated return of spring chinook to the Clackamas River. (source StreamNet).



Habitat potential for spring chinook in the upper Clackamas River

Overall potential of habitat in the Clackamas River for spring chinook has been greatly reduced relative to the restored reference condition. Current abundance potential is about 23 percent of the potential under the reference condition (Figure 25). Overall productivity as a function of habitat has been reduced by about 7 percent relative to the reference but remains about 3.5 returns/spawner even with harvest. On the other hand, the habitat retains about 80 percent of the potential life history diversity. This is higher than for most other populations in this assessment and reflects the heavy use of the mainstem by spring chinook (especially the upper mainstem reaches) with less use of the diversity of habitats in the tributaries.

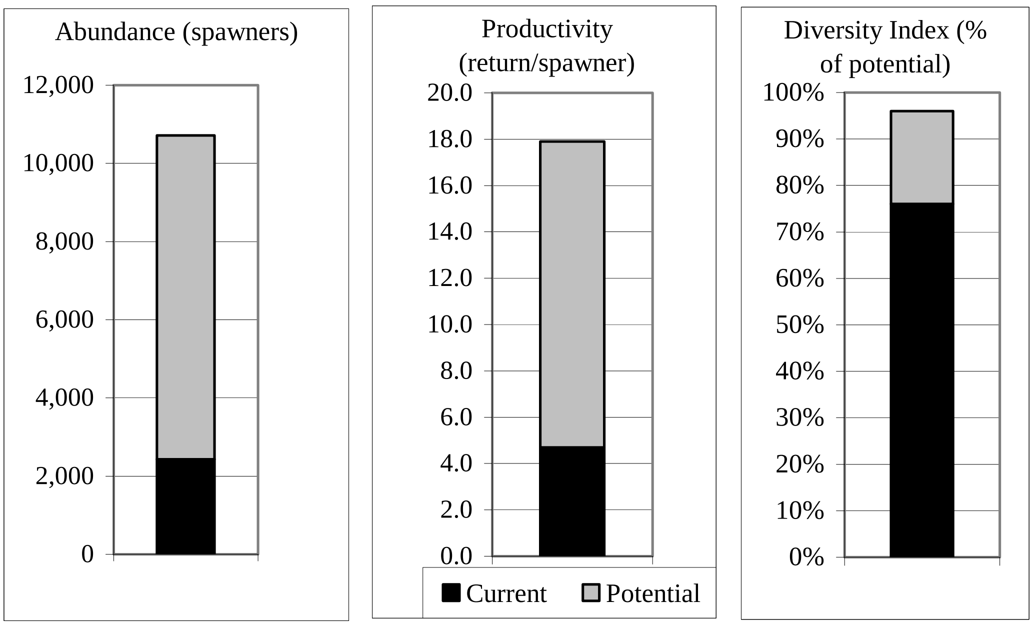
Habitat Priorities by Geographic Area

Current habitat potential for spring chinook in the Clackamas is mainly in the mainstem areas, especially the middle Clackamas area (reaches from above North Fork Reservoir to Oak Grove) and the upper Clackamas (Figure 26). Similarly, most of the protection value for the Diversity Index under the current habitat condition was in the middle and upper mainstem reaches of the Clackamas.

Figure 25. EDT estimates of habitat potential in the Clackamas River for spring chinook. Graphs show figures without harvest.

Upper Clackamas Spring Chinook

Scenario	Diversity index	Productivity	Abundance
Current without harvest	76%	4.7	2,434
Current with harvest	73%	3.5	1,620
Reference potential	96%	17.9	10,716



May 11, 2004

The greatest habitat restoration value for spring chinook in the Clackamas was in the lower Clackamas mainstem (Figure 26). The second restoration value for spring chinook was the lower Willamette area (Portland). The high restoration value of these lower reaches in part reflects the benefits afforded by improving conditions for adult and juvenile migrants that pass through the lower Willamette and lower Clackamas reaches. Conditions for spring chinook spawning in the lower Clackamas mainstem were also reduced by habitat constraints (next section). The third restoration priority is the middle Clackamas (Figure 26). As noted above for other populations, this refers to the effect of the PGE reservoir and dam. Restoration of this area in the model extended the high priority habitat in the reaches above North Fork Reservoir down to the location of River Mill Dam.

Constraints on coho habitat potential in the lower Clackamas River

Major limiting factors on spring chinook potential in the Clackamas River were Temperature in the lower tributaries and lower mainstem, Habitat Diversity in almost all areas, and loss of Key Habitat Quantity due to narrowing and straightening of the channel (Figure 27). Water Temperature was a particularly important limiting factor in the Lower

Clackamas mainstem where it limited spawning success. This was also a problem for fall chinook spawning in the lower mainstem (Figure 16). Spring chinook spawning begins in September when temperatures in the lower river, including the lower basin tributaries, are at high levels.

As discussed for other populations, the decline in Habitat Diversity in almost all cases reflects a reduction in the amount of large wood due to changes in riparian forests and stream clearing. Obstructions were an important limiting factor for spring chinook in the Middle Clackamas area because of the survival impacts of the PGE dams.

In the lower Willamette (Portland) area, Chemicals (pollutants), Habitat Diversity and Key Habitat Quantity were important limiting conditions for Clackamas Spring Chinook (Figure 27). These limitations have been discussed above for other populations. Pathogens, however, was an additional important factor in the lower Willamette. Pathogens showed up a limiting factor for coho in the lower Willamette as well. The Willamette River is has *Certatomyxis shasta* and its virulence is proportional to temperature in the EDT analysis. The timing of adult and juvenile chinook (and coho) migrants through the lower Willamette that they are exposed to the disease as

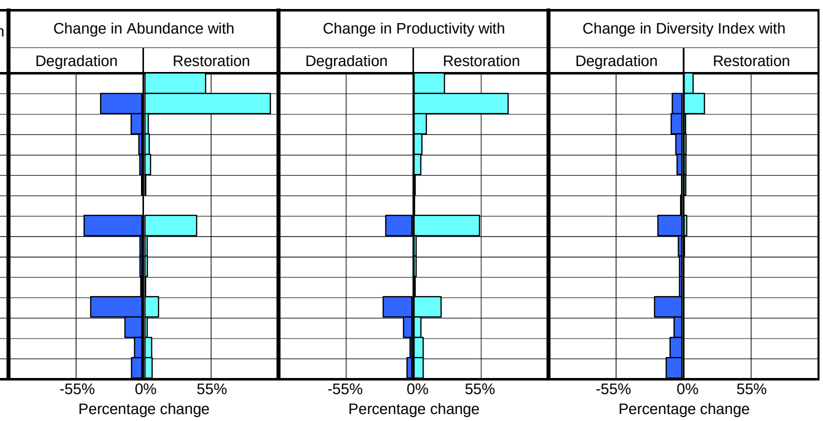
Figure 26. Clackamas River spring Chinook habitat priorities. Protection priorities are determined by the change in a performance attribute with degradation while restoration priories are given by the change in performance with restoration.

Clackamas River Spring Chinook

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection Rank	Restoration Rank
Portland	13	2
Lower Clackamas	5	1
Eagle(CLA)	6	6
North Fork Eagle(CLA)	7	5
Clear(CLA)	8	7
Deep(CLA)	12	10
Lower Clack Tribs	12	12
Middle Clackamas	2	3
Fish(CLA)	10	9
Roaring(CLA)	9	9
Middle Clack Tribs	11	11
Upper Clackamas	1	4
Collowash(CLA)	4	8
Hot Springs Fork(CLA)	5	7
Upper Clack Tribs	3	5

11-May-04



temperature is increasing in the spring.

Figure 27. Clackamas River spring Chinook attribute effects. The change in productivity with restoration of an attribute is given by the size of the black dot, which is proportional to the overall restoration value given by the open circles to the left. A large black dot in an area with little overall restoration value (given by the size of the open circle) indicates little change in performance with restoration of the attribute

Clackamas River Spring Chinook
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	**Protection benefit**	**Restoration benefit**	*Channel stability/landsc.1/*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Portland		○ High		● Medium			● Low	● Low	● Medium				● Low	● Medium		● Low		● Medium
Lower Clackamas	○ Low	○ High	● Medium	● Low	● Low		● Low	● Low	● Low	● Low			● Low	● Medium	● Medium	● High		● Low
Eagle(CLA)	○ Low	○ Low			● Low		● Low						● Low	● Low	● Medium	● High		● Low
North Fork Eagle(CLA)	○ Low	○ Low			● Low								● Low		● Medium	● High		● Low
Clear(CLA)	○ Low	○ Low		● Low	● Low		● Low	● Low	● Low	● Low		● Low	● Low	● Low	● Low	● High		● Low
Deep(CLA)				● Medium			● Low	● Low					● Low		● Medium	● High		● Medium
Lower Clack Tribs				● Low			● Low		● Low			● Low			● Medium			● Medium
Middle Clackamas	○ High	○ Medium						● Low	● Low	● Low	● Medium			● Low	● Medium			● Low
Fish(CLA)			● Low				● Low	● Low	● Low						● Medium	● Medium		● Low
Roaring(CLA)									● Low						● Low			● Medium
Middle Clack Tribs							● Low		● Low						● Medium			● Low
Upper Clackamas	○ High	○ Medium							● Low	● Low					● Low			● Low
Collowash(CLA)	○ Medium	○ Low													● Low			● Low
Hot Springs Fork(CLA)	○ Low	○ Low							● Low		● Medium				● Low			● Medium
Upper Clack Tribs	○ Medium	○ Low					● Low							● Low	● Low			● Medium

1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

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Key to strategic priority

○ / ● (large)	High
○ / ● (medium)	Medium
○ / ● (small)	Low
(empty)	Indirect or General

Habitat Assessment by Geographic Area

Our assessment of the Clackamas River addressed habitat conditions for three salmonid species and six populations. The preceding discussion focused on how habitat conditions across the Clackamas affect potential performance of each of the six populations, i.e. Geographic Areas within populations. This section will discuss each of the 15 Geographic Areas in the Clackamas River (Table 2) and the conditions that limit populations within each area, i.e. populations within Geographic Areas. In this way, limiting conditions that occur across one or more populations can be identified while Geographic Areas can be prioritized in terms of their potential impact on the mix of salmonid populations in the Clackamas River.

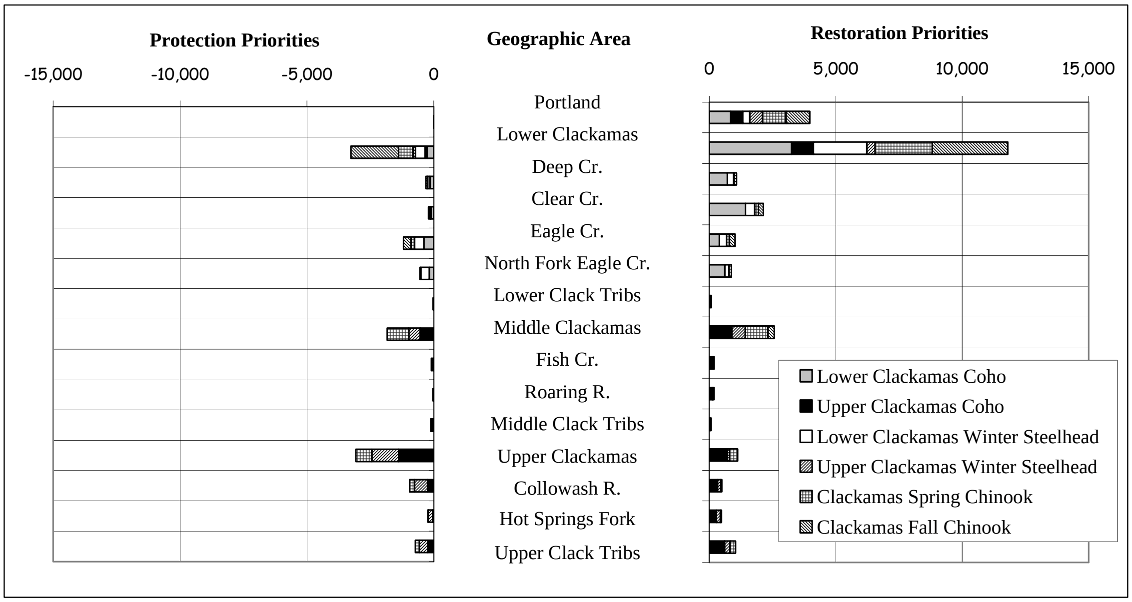
Of course, all Geographic Areas are not relevant to each population. Conditions in the Eagle Creek Geographic Area, for example, have no impact on upper Clackamas steelhead while conditions in the Collowash area have no impact on lower Clackamas steelhead. Any Geographic Area can impact up to six populations depending on how anadromous salmonids use the Clackamas River within the EDT assessment.

This brings up an important caveat: this study only assessed the effect of conditions within a reach on fish survival and capacity within that reach--it did not deal with causes of conditions. While some habitat limitations are proximal, i.e. originate at a local level, others are systemic and are the result of cumulative conditions throughout the watershed. Large wood and channel form are examples of proximal limiting factors (although arguments can be made that these are influenced by the accumulation of upriver conditions as well). Flow, sediment and temperature are examples of systemic problems that are perceived by fish at a local level (and would be identified in this assessment) but develop as a result of the accumulation of conditions upstream. For example, temperature is an important limiting factor in the lower Clackamas area, but conditions in the lower Clackamas area have only a minor impact on the summer water temperature. Instead, water temperature in the lower Clackamas is the result of decreased riparian forests in the tributaries and mainstem, ponding of water behind dams and other upriver factors. The point is that even though many of the smaller tributaries were ranked low in terms of their overall contribution to abundance of the focal species, these areas may be the source or origin of conditions that are identified as limiting factors in larger downstream areas. In addition, the discussion above for each population noted that these smaller streams can make important contributions to the life history diversity of the population even if they do not contribute greatly to abundance. Restoration of lower ranked areas may be entirely appropriate as solutions to problems limiting fish production in higher ranked areas and to increase diversity.

Basin-wide comparison across Geographic Areas

Figure 28 displays the results of the EDT analysis for all Geographic Areas for all species and populations combined. This figure shows the effect of degrading conditions further (protection priority) and of restoring conditions (restoration priorities) in each geographic area on the equilibrium abundance of each of the six populations. Protection priorities describe how the Clackamas system current operates. Restoration priorities

Figure 28. Protection and Restoration priorities for each Geographic Area in the Clackamas River in regard to abundance of all six focal species/populations.



describe the potential of each area in terms of what might be possible with restoration. Table 3 shows the relative ranking of each Geographic Area in regard to overall protection and restoration potential for all six populations combined.

Generally, upper Clackamas areas had higher protection value than restoration value (Figure 28). This indicates that habitat conditions in the upper Clackamas areas are generally good, making protection a priority over restoration. In the lower Clackamas areas, the reverse was the case. Conditions are generally poor and restoration of habitat was a greater priority than was protection of current conditions. However, areas can have both a high protection and a high restoration priority. This indicates that even though current conditions are degraded (and therefore there is restoration potential) these areas are still key to the current biological performance of the population (and therefore have a high protection value). The lower Clackamas mainstem is a good example of this. The lower Clackamas mainstem area had the number one rank in the entire assessment for both protection and restoration (Table 3). Conditions in the lower mainstem are clearly important to all six populations (Figure 28). As will be discussed below, the lower mainstem area is degraded but the area has a key biological function for all six populations. The Portland Area (lower Willamette) had the lowest protection ranking of all areas in the assessment but was ranked second in terms of overall restoration benefit for the Clackamas River (Table 3). Currently, due to habitat limitations, adults and juveniles appear to use the lower Willamette largely as a migration corridor for which current habitat conditions are not limiting—life histories that might use the lower river for juvenile growth and rearing are trimmed out of the model because of current habitat conditions leaving only those that move through the are quickly. However, with restoration, the lower Willamette added considerable juvenile rearing capacity to the Clackamas and significantly increased potential abundance of the Clackamas populations.

Table 3. Overall protection and restoration ranks for each of 15 Geographic Areas in the Clackamas River across three fish species and six populations.

Geographic Area (15 total areas)	Protection Rank	Restoration Rank
Portland	15	2
Lower Clackamas	1	1
Deep Cr.	10	5
Clear Cr.	8	4
Eagle Cr.	5	6
North Fork Eagle Cr.	7	7
Lower Clackamas Tributaries	14	12
Middle Clackamas	3	3
Fish Cr.	12	13
Roaring R.	13	14
Middle Clackamas Tributaries	11	15
Upper Clackamas	2	8
Collowash R.	4	10
Hot Springs Fork	9	11
Upper Clackamas Tributaries	6	9

Overview of Completed Restoration and Protection Actions

The Clackamas River Basin Council (CRBC) and its partners (U.S. Forest Service, Bureau of Land Management, PG&E, other organizations and landowners) are working in the to improve watershed functions and conditions in the Clackamas River Subbasin.

The following is a selection of the Council and partner organization projects, studies and monitoring actions used to identify priority projects:

Projects

- ***Stream stewards.*** Strategic riparian improvement and tree plantings based on aerial photos and GIS and then willing landowners in lower basin.

- ***Large wood.*** The Council has place large wood in Eagle, Foster and Clear Creeks. The Council has treated 3.5 miles and plans to do 2-3 miles this summer.

- ***Fish passage barriers.*** The Council is working with Clackamas County in Clear and Foster Creeks to remove high priority road crossing fish passage barriers, completing four of the twenty highest priority projects, and planning to complete three to four more this summer.

- ***Side channel restoration.*** The Council and partners have completed one side channel restoration project in the upper subbasin and inventoried ten potential sites in lower basin. Construction on one side channel in the lower subbasin will begin this summer.

- ***Knotweed and other invasive weed removal.*** Subbasin-wide survey of invasive weeds is ongoing. Treatment has begun along mainstem Clackamas River above Carver and spot treatments in high priority tributaries of Clear Creek and Eagle creek. In addition the Council is working with the Forest Service land to identify locations and plan invasive weed treatments.

In addition to these projects the Council's partner organizations are pursuing other habitat restoration action and strategies. For example, under the Northwest Forest Plan, the Forest Service and the Bureau of Land management are protecting riparian areas, and late-successional reserves. Both agencies are engaged in restoration actions, including restoring riparian areas, addressing fish passage barriers, and controlling road-related sediment. PG&E continues to address fish passage and other issues at their dams.

Portland: Lower Willamette

Overall Protection Rank: 15

Overall Restoration Rank: 2

Conditions in the lower Willamette River affect the performance of all six populations in the Clackamas River. This assessment showed that conditions in the lower Willamette can contribute significantly to the potential biological performance of fish in the Clackamas River. In fact, it is apparent that the Clackamas River and the lower Willamette River form a contiguous habitat unit. This expanded view of the Clackamas can form a useful focus for restoration and management of coho, chinook and steelhead in the Clackamas River.

Current conditions in the Portland (lower Willamette) area are degraded and the area had almost no protection value for the six Clackamas populations. The assessment found that salmon and steelhead used the area almost entirely as a migration corridor. This is consistent with studies of fish use of the lower Willamette River that found that most juvenile salmonids move through the area in less than two weeks (Friesen and others 2002). However, restoration of conditions in the lower Willamette illustrated the potential of the area to contribute to tributary populations such as those from the Clackamas. For all six populations combined, the Portland area was the second ranked restoration priority. The Portland area had a moderate overall restoration ranking and relatively high rankings for Clackamas spring chinook (restoration rank 2 out of 13), fall chinook (restoration rank 3 out of 7) and upper Clackamas steelhead (restoration rank 3 out of 8).

Limiting Factors

Limiting environmental attributes in the Portland area included Chemical pollutants, loss of Habitat Diversity, Pathogens, Predation (the result of large numbers of introduced fish species) and loss of Key Habitat (Figure 29). The lower Willamette River has a host of water pollutant problems from local and upriver sources. Loss of Habitat Diversity and the quantity of Key Habitat types are the result of channelization and dredging of the lower river that has eliminated much of the shallow water habitat that would provide rearing habitat for juvenile life stages (McConnaha 2003). Harassment due to boating and other encroachment of human activities on salmonids is pervasive within an urbanized area. Predation is suggested as a limiting factor due to the presence of numerous non-native fish species in the lower Willamette River (Farr and Ward 1993). The limiting effect of pathogens reflects the presence of large numbers of hatchery fish in the lower Willamette and endemic *C. shasta* (a fish pathogen).

Restoration Hypotheses and Strategies

Chemical Contaminants

Because of the level of pollution in lower Willamette River sediments, the Portland Harbor was added to the federal Superfund cleanup list in December 2000. The Portland area is also the recipient of pollutants from the entire upstream Willamette watershed. Pollutants introduced through local and upriver industrial discharges, toxics carried by stormwater, and other sources have contributed to elevated levels of many urban pollutants.

Hypothesis 1. ***The Clackamas River and the Portland reach of the Willamette form an integrated habitat unit that is a useful basis for restoration and management of lower Willamette River fish populations.***

Hypothesis 2. ***Reducing pollutant inputs into the Lower Willamette River from local and upriver sources will improve the survival of Clackamas River juvenile spring chinook and coho salmon and winter steelhead.***

Strategy 2.1. Reduce pollutant loads into the Lower Willamette River through improved implementation of BMPs and other measures in the Portland Metropolitan Area and the Upper Willamette River and tributaries.

Strategy 2.2. Reduce input of pollutants to the Willamette River through tributaries by concerted efforts to reduce pollutant discharge within Tryon Creek, Johnson Creek, Kellogg Creek, Abernethy Creek and other tributaries. Much of the pollutant inflow

Figure 29. Protection and restoration rankings for the Portland (lower Willamette) area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Portland (Lower Willamette)

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho	6	5	6		●	•		•	•	⬤	•			•	•		•		●
Upper Coho	9	4	9		●					●	•			•	•				●
Lower Steelhead	6	5	6		●	•		•		•	•			•	•				•
Upper Steelhead	8	3	8		●					•	•				•				•
Fall Chinook	6	3	7		•	•		•	•	●	•			•	•		•		●
Spring Chinook	13	2	13		●			•	•	●				•	●		•		●
Average Area Rank	8.0	3.7	8.2																

likely comes from street and parking lot runoff and measures should focus on reducing these inputs as well as known point sources.

Shallow Water Habitats

There have been dramatic reductions in shallow water areas throughout the lower Willamette River that are important for spring chinook and coho salmon and winter steelhead rearing and out-migration.

Hypothesis 3. ***Increasing shallow water habitats in Lower Willamette River will improve the survival will improve the survival and increase capacity of Clackamas River juvenile spring chinook and coho salmon and winter steelhead.***

Strategy 3.1. Identify opportunities to restore shallow water habitat in the lower Willamette River.

Strategy 3.2. Designate the Ross Island and Oaks Bottom areas as habitat restoration zones. Investigate potential to reconnect Oaks Bottom to the Willamette River.

Strategy 3.3. Designate lower reaches of Tryon Creek, Johnson Creek, Kellogg Creek, Abernethy Creek and other tributaries as habitat restoration zones. Take measures to restore these as off channel habitat and encourage use by juvenile anadromous salmonids.

Protection Hypotheses and Strategies

Lower Clackamas River

Protection Priority: 1

Restoration Priority: 1

The lower Clackamas River mainstem influences performance of all six populations. With all six populations combined, the lower Clackamas was the number one ranked area in the Clackamas River for both protection and restoration (Table 3). Conditions are relatively degraded and protection ranks for all populations except fall chinook were low. Because this area has virtually all potential spawning habitat in the Clackamas for fall chinook, it was the number one protection priority for this population despite the current habitat limitations. All six populations use the lower Clackamas to varying degrees and would benefit from improved conditions in this area, and, as a result, the lower Clackamas area had the top restoration rating for four of the six populations.

Upper river coho and steelhead used the lower river mainly for migration and so restoration was a lesser priority for these populations.

Limiting Factors

Limiting factors include Predation (resulting from the large number of introduced fish species present), Sediment (for those populations that potentially use the lower river for spawning) and degraded Channel Stability (Figure 30). The latter factor is the result of diking and channelization of the lower river and the restricted connection between the river and the floodplain. Narrowing of the channel between dikes has also decreased Key Habitat Quantity in the lower Clackamas area (Figure 30). Temperature was a major limiting factor for both chinook populations that commence spawning in September when water temperatures are extremely high. Chemical pollutants and hatchery impacts (Competition with hatchery fish and Pathogens) were also important limiting factors in the lower Clackamas. Changes in the sediment patterns and storage are also impacting fish populations. The river channel in the first two miles below the River Mill dams is coarsening and downcutting, which impacts the quality and quantify of spawning habitats. Sediments, nutrients and toxins also flow in the lower river from urbanizing tributaries, such as Deep, Rock and Richardson Creeks.

Restoration Hypotheses and Strategies

Side Channels and other Floodplain Habitats

Confinement of the Lower Clackamas River channel, loss of large wood, and modified riparian areas has contributed to the loss of side-channel and other habitats. Slow water habitats, such as side channels, alcoves and the margins of complex wood jams, provide a diverse array of water depths and velocities, which provide cover for adult fish and rearing and refuge areas for juveniles.

Hypothesis 4: ***Restoring historic channel structure, side-channels and other complex habitats in the Lower Clackamas River will improve survival for pre-spawning migrant and juvenile coho salmon, spring chinook salmon and winter steelhead.***

Figure 30. Protection and restoration rankings for the Lower Clackamas area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Lower Clackamas

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho	5	1	6	●	•	●	•	•	•	⬤	•			•	●	●	•		●
Upper Coho	6	4	9			•			•	●				•	●		•		●
Lower Steelhead	4	1	6	•	•	●	•	•	•	•	•			●	●	●	●		•
Upper Steelhead	5	5	8			•								•	●				•
Fall Chinook	1	1	7	●	•			•	•	•	•			•	●	●	⬤		•
Spring Chinook	5	1	13	●	•	•		•	•	•	•			•	●	●	⬤		•
Average Area Rank	4.3	2.2	8.2																

Strategy 4.1. Reconnect historic side channels within and along the Lower Clackamas River.

Strategy 4.2. Remove revetments and dikes to allow the Lower Clackamas River to access historic floodplain habitat.

Large Wood

Processes that transport and deliver large wood to the Lower Clackamas River have been altered through modified riparian areas, removal of wood, and channel confinement. As a result, it is necessary Large wood in the river channel, alcoves, and side channels, provide complex habitats and low water velocities, which contributes to improved areas for spring chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered in sections along the Lower Clackamas River. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river.

Hypothesis 5: ***Improved riparian conditions, width and connectivity along the Lower Clackamas River will increase survival for the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 5.1. Add large wood to the existing and new backwater habitats (side-channels, etc.) along the Lower Clackamas River as individual pieces and in large logjams.

Strategy 5.2. Restore floodplain and riparian vegetation, particularly to accelerate late-successional forest structure along the Lower Clackamas River.

Deep Creek

Overall Protection Priority: 10
Overall Restoration Priority: 5

In the context of the Clackamas River as a whole and for all six populations, Deep Creek received a moderately low Protection Rank (10 of 15) but a moderately high Restoration Rank (5 of 15). Deep Creek Watershed provides valuable habitat for four of the six populations but especially for lower Clackamas coho, lower Clackamas steelhead and spring Chinook (Figure 31).

Limiting Factors

The Deep Creek watershed has an abundance of nursery operations and some urbanization. Presumably as a result, major limiting factors for all populations present

Figure 31. Protection and restoration rankings for the Deep Creek Watershed and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Deep Creek

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho	4	3	6		•			•	•	●		⬤			•	●	●		●
Upper Coho																			
Lower Steelhead	3	3	6		•			●		•		⬤		•	•	●	●		●
Upper Steelhead																			
Fall Chinook	4	6	7		●			•	•							●	⬤		•
Spring Chinook	12	10	13		●			•	•					•		●	⬤		●
Average Area Rank	5.8	5.5	8.0																

were Sediment and Chemicals (pollutants). Summer water Temperature was also a major factor, especially for the two chinook populations that are exposed to high September temperatures during spawning. Obstructions from culverts and their impacts on adult and juvenile passage are a key factor limiting winter steelhead and coho salmon.

Restoration Hypotheses and Strategies

Fish Passage Obstructions

Fish passage obstructions were particularly important factor in Deep Creek where the overall restoration value was relatively high. This assessment included nine culverts in Deep Creek. While not all obstructions were inventoried, many of the most important fish passage barriers were included in the analysis.

Hypothesis 6: ***Improving fish passage at road crossing culverts will increase habitat quantity and improve survival for Lower Clackamas River adult spawning and juvenile coho salmon and winter steelhead in Deep Creek and tributaries.***

Strategy 6.1. Improve fish passage at identified fish passage barriers at road crossing culverts and other obstructions on Deep Creek and tributaries.

Water Temperatures

Increased water temperatures during the summer and early fall impact fish populations.

Hypothesis 7: ***Improved canopy cover over stream channels will improve summer and early fall water temperatures, increasing survival for juvenile coho salmon, winter steelhead and spring chinook salmon in Deep Creek and tributaries.***

Strategy 7.1. Improve water temperatures by increasing canopy cover over Deep Creek and tributaries.

Chemical Contaminants

Chemical contaminants from roads, agricultural practices and increasing development have impacted fish populations in Deep Creek.

Hypothesis 8: ***Reducing chemical contaminants delivered to the aquatic system will improve habitat spawning habitat condition and improve survival for winter steelhead and coho salmon in Deep Creek and Tributaries.***

Strategy 8.1. Reduce chemical contaminant delivery to stream channels from roads, agricultural practices, and development through the application of appropriate BMPs.

Sediment

Sediment deposition is impacting spawning habitats, particularly for winter steelhead and coho salmon.

Hypothesis 9: ***Reducing sediment transport and delivery to stream channels will improve spawning habitat condition and improve survival for winter steelhead and coho salmon in Deep Creek and tributaries.***

Strategy 9.1. Reduce sediment delivery to stream channels from roads, agricultural practices, and development through the application of appropriate BMPs in the Deep Creek Watershed.

Protection Hypotheses and Strategies

While is extensive habitat modification within the Deep Creek Watershed, some high quality riparian and aquatic habitats remain.

Hypothesis 10: ***Protecting high quality riparian habitats, in association with restoration actions to increase habitat area and connectivity in the Deep Creek Watershed will increase the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 10.1. Protect high quality floodplain, and riparian habitats along Deep Creek and tributaries.

Clear Creek

Overall Protection Priority: 8
Overall Restoration Priority: 4

Conditions in Clear Creek impact four of the six populations (Figure 32). Fall chinook spawn in the lower reaches while coho, steelhead and spring chinook use most of

Figure 32. Protection and restoration rankings for the Clear Creek area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Clear Creek

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho	1	2	6		•	•		•	•	●		⬤		•	•	●	•		●
Upper Coho																			
Lower Steelhead	4	2	6		•			•	•	•		⬤		●	•	●	●		•
Upper Steelhead																			
Fall Chinook	3	5	7		•			•	•		•				•	•	⬤		•
Spring Chinook	8	7	13		•	•		•	•	•	•		•	•	•	•	⬤		•
Average Area Rank	4.0	4.0	8.0																

the accessible reaches. For the entire Clackamas Basin and for all six populations, Clear Creek received a moderate rating for Protection (8 of 15) and a relatively high rank for Restoration (4 of 15). There are some remaining areas within the Clear Creek Watershed, particularly in the upper watershed, that retain high quality riparian and stream habitats that warrant protection.

Limiting Factors

Temperature was an important limiting factor for all four populations especially the two Chinook populations that spawn in September when water temperatures are at their maximum. Obstructions due to culverts and road crossings are a key factor limiting winter steelhead and coho salmon. Other important factors impacting fish populations in Clear Creek and tributaries are habitat diversity (from limited large wood in stream channels) and loss of Key Habitat Quantity due to channelization and channel restrictions. Whirling disease has been identified in a private hatchery in the watershed although no recent outbreaks in natural populations have been identified. However, because of its potential impact on fish, disease in Clear Creek warrants continued monitoring.

Restoration Hypotheses and Strategies

Fish Passage Obstructions

Fish passage obstructions were particularly important factor in Clear Creek where the overall restoration value was relatively high. This assessment included 5 culverts in Clear Creek. While not all obstructions were inventoried, many of the most important fish passage barriers were included in the analysis.

Hypothesis 11: ***Improving fish passage at road crossing culverts and other fish passage barriers will increase habitat quantity and improve survival for Lower Clackamas River adult spawning and juvenile coho salmon and winter steelhead in Clear Creek and tributaries.***

Strategy 11.1. Improve fish passage at identified fish passage barriers at road crossing culverts and other obstructions on Clear Creek and tributaries.

Water Temperatures

Increased water temperatures during the summer and early fall have impacted fish populations.

Hypothesis 12: ***Increased canopy cover over Clear Creek and tributary stream channels will improve summer and early fall water temperatures, increasing survival for juvenile coho salmon, winter steelhead and spring chinook salmon.***

Strategy 12.1. Improve water temperatures by increasing canopy cover over Clear Creek and tributaries.

Large Wood

Processes that transport and deliver large wood to the Clear Creek and Tributaries have been altered through modified riparian areas, removal of wood, and channel confinement. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., where there are river-side roads). Large wood in the stream and tributaries provide complex habitats and low water velocities, which contributes to improved areas for spring chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered in sections along the Clear Creek and tributaries. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river.

Hypothesis 13: ***Increased large wood in the Clear Creek and tributary channels and improved riparian conditions, including width and connectivity will increase survival for the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 13.1. Add large wood to Clear Creek and tributary channels as individual pieces and in large logjams.

Strategy 13.2. Restore floodplain and riparian vegetation along Clear Creek and tributary channels.

Protection Hypotheses and Strategies

While there is extensive habitat modification within the Clear Creek Watershed, some high quality riparian and aquatic habitats remain, particularly along portions of the mainstem and the upper watershed.

Hypothesis 14: ***Protecting high quality riparian habitats, in association with restoration actions to increase habitat area and connectivity will increase the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 14.1. Protect high quality floodplain and riparian habitats along Clear Creek and tributaries.

Eagle Creek

Protection Priority: 5

Restoration Priority: 6

Conditions in Eagle Creek affect four of the six populations. Eagle Creek includes Eagle Creek National Fish Hatchery. Three natural waterfalls occur. These have been laddered to allow fish passage into the upper watershed. Overall, Protection of conditions in Eagle Creek received a moderately high rating (5 of 15) and a similar

Figure 33. Protection and restoration rankings for the Eagle Creek area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Eagle Creek

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho	2	4	6			•		•	•	⬤		●		•	•	●	•		•
Upper Coho																			
Lower Steelhead	2	2	6			•		•		•		●		•	•	●	●		•
Upper Steelhead																			
Fall Chinook	2	2	7					•							•	●	⬤		
Spring Chinook	6	6	13			•		•						•	•	●	⬤		•
Average Area Rank	3.0	3.5	8.0																

Restoration rating (6 of 15). For individual populations, Eagle Creek was ranked as a number two priority for Protection for coho, steelhead and fall chinook and a 6 (out of 13) for spring chinook (Figure 33).

Limiting Factors

High water Temperatures and Sediment were the major limiting factors in Eagle Creek. Obstructions were a lesser problem in Eagle Creek compared to the other lower river tributaries. This system has three natural waterfalls that have been laddered and two artificial obstructions.

Restoration Hypotheses and Strategies

Water Temperature

Increased water temperatures during the summer and early fall have impacted fish populations.

Hypothesis 15: ***Improved canopy cover over Eagle Creek and tributary stream channels will improve summer and early fall water temperatures, increasing survival for juvenile coho salmon, winter steelhead and spring chinook salmon.***

Strategy 15.1. Improve water temperatures by increasing canopy cover over Eagle Creek and tributaries.

Sediment

Sediment deposition is impacting spawning habitats, particularly for winter steelhead and coho salmon.

Hypothesis 16: ***Reducing sediment transport and delivery to Eagle Creek and tributary stream channels will improve spawning habitat condition and improve survival for winter steelhead and coho salmon.***

Strategy 16.1. Reduce sediment delivery to stream channels from roads and development through the application of appropriate BMPs along Eagle Creek and tributaries.

North Fork Eagle Creek

Protection Priority: 7

Restoration Priority: 7

Conditions in North Fork Eagle Creek affected three of the six populations (Figure 34). Overall, this area received a moderate rank for both Protection and Restoration (7 of 15). However, North Fork Eagle Creek was ranked number one for protection in regard to lower Clackamas winter steelhead although it received only moderate rankings for the other populations (Figure 34).

Limiting Factors

Limiting factors in North Fork Eagle Creek are similar to those in other lower watershed tributaries. High water Temperature was a key factor for spring chinook; increased fine sediment has affected spawning success of all three populations. Coho and steelhead, species which would use the upper reaches of the stream, are affected by Obstructions due to culverts and road crossings.

Restoration Hypotheses and Strategies

Water Temperature

Increased water temperatures during the summer and early fall have impacted fish populations.

Figure 34. Protection and restoration rankings for the North Fork Eagle Creek area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: North Fork Eagle Creek

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho	3	5	6			•		•	•	●		●				●	•		●
Upper Coho																			
Lower Steelhead	1	4	6			•		•				●		•	•	●	•		●
Upper Steelhead																			
Fall Chinook																			
Spring Chinook	7	5	13			•								•		●	⬤		•
Average Area Rank	3.7	4.7	8.3																

Hypothesis 17: ***Improved canopy cover over stream channels will improve summer and early fall water temperatures, increasing survival for juvenile coho salmon, winter steelhead and spring chinook salmon in North Fork Eagle Creek and tributaries.***

Strategy 17.1. Improve water temperatures by increasing canopy cover over North Fork Eagle Creek and tributaries.

Sediment

Sediment deposition is impacting spawning habitats, particularly for winter steelhead and coho salmon.

Hypothesis 18: ***Reducing sediment transport and delivery to stream channels will improve spawning habitat condition and improve survival for winter steelhead and coho salmon in North Fork Eagle Creek and tributaries.***

Strategy 18.1. Reduce sediment delivery to stream channels from roads through the application of appropriate BMPs along North Fork Eagle Creek and tributaries.

Lower Clackamas Tributaries

Overall Protection Priority: 14

Overall Restoration Priority: 12

The collection of small streams making up the Lower Clackamas Tributary area includes Rock, Richardson, Foster, Goose, Cow and Sieben creeks. Overall, this area received low rankings for both Protection (14 of 15) and Restoration (12 of 15). Conditions in these tributaries directly affect four of the six populations but also received low Protection and Restoration rankings for each of the populations (Figure 35).

Although the lower Clackamas Tributaries were ranked near the bottom in regard to Protection and Restoration priorities, this may be underestimating their impact on the Clackamas River. As was discussed above, many problems in the lower Clackamas mainstem (ranked first in overall Protection and Restoration priorities), such as temperature and sediment, originate upstream and in tributaries like those included in this area. Solutions to problems in the lower Clackamas mainstem may lie in these smaller tributaries.

Limiting Factors

Habitat problems in these streams are common to all the lower basin tributaries: high summer water temperature, increased fine sediment and loss of Key Habitat quantity. Surprisingly, Obstructions did not show up as a limiting survival factor in the lower tributaries although it is emphasized that this assessment did not include all

Figure 35. Protection and restoration rankings for the Lower Clackamas Tributaries area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Lower Clackamas River Tributaries

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho	5	6	6	•	•		•	•	•	●	•					●	•		●
Upper Coho																			
Lower Steelhead	5	6	6		•			●	•	•	•			•	•	●	●		●
Upper Steelhead																			
Fall Chinook	5	7	7		●			•	•							●	⬤		●
Spring Chinook	12	12	13		•			•		•			•			●			●
Average Area Rank	6.8	7.8	8.0																

obstructions and it is likely that culverts and other obstructions exist in these streams.

Water Temperature

Increased water temperatures during the summer and early fall have impacted fish populations.

Hypothesis 19: ***Improved canopy cover over stream channels will improve summer and early fall water temperatures, increasing survival for juvenile coho salmon, winter steelhead and spring chinook salmon in Lower Clackamas tributaries.***

Strategy 19.1. Improve water temperatures by increasing canopy cover over Lower Clackamas tributaries.

Sediment

Sediment deposition is impacting spawning habitats, particularly for winter steelhead and coho salmon.

Hypothesis 20: ***Reducing sediment transport and delivery to stream channels will improve spawning habitat condition and improve survival for winter steelhead and coho salmon in Lower Clackamas tributaries.***

Action 20.1. Reduce sediment delivery to stream channels from roads through the application of appropriate BMPs along Lower Clackamas tributaries.

Large Wood

Processes that transport and deliver large wood to the Lower Clackamas tributaries have been altered through modified riparian areas, removal of wood, and channel confinement. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., where there are river-side roads). Large wood in the stream and tributaries provide complex habitats and low water velocities, which contributes to improved areas for spring Chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered in sections along the Lower Clackamas tributaries. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river.

Middle Clackamas River

Protection Priority: 3

Restoration Priority: 3

The Middle Clackamas area consists of the mainstem of the Clackamas River from North Fork Dam to Oak Grove Fork, including North Fork Reservoir. At the scale of the entire Clackamas River and all six species, the middle mainstem reach ranked third for both Protection and Restoration. Habitat in the middle mainstem affects four of the six populations (Figure 36). The aquatic and riparian habitats within and along the Upper Middle River have high protection values, particularly for spring chinook salmon (protection rank 2 out of 13 possible). The area had high restoration values for coho (restoration rank 2 out of 9), winter steelhead (restoration rank 1 out of 8) and spring chinook (restoration rank 3 out of 13). Within this analysis, fall chinook were hypothesized to spawn historically in the river reaches currently inundated by North Fork Dam. This area has no protection value because of the reservoir and a moderate restoration value for fall chinook (restoration rank 4 out of 7).

Limiting Factors

Key factors limiting fish populations in the middle Clackamas River are loss of Habitat Diversity, increased fine Sediment and loss of Key Habitat Quantity. Most of the

Figure 36. Protection and restoration rankings for the Middle Clackamas River area and restoration effects of survival attributes on six populations from the Clackamas River

Geographic Area: Middle Clackamas

Population	Area Rank: Protection Rank	Area Rank: Restoration Rank	Area Rank: Out of	Survival Factor Priority for Restoration: *Channel stability/landsc.1/*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Lower Coho																			
Upper Coho	3	2	9			•		•	•	●	•	●			•	●			•
Lower Steelhead																			
Upper Steelhead	3	1	8						•	●	•	•			•	●			•
Fall Chinook	7	4	7					•	•	●	•			•	•	●			⬤
Spring Chinook	2	3	13						•	•	•	●			•	●			•
Average Area Rank	3.8	2.5	9.3																

loss of habitat diversity is the result of reductions in large wood in the river, channel confinement from roads and other actions, impacts to riparian areas, and loss of spawning habitat within the North Fork Reservoir. Forest Service Road 46, which parallels large sections of the river, prevents river meandering, restricts the channel, all of which increases channel velocities and scour, minimize complex slow water habitats such as side channels. The river cannot meander through the road and cannot access historic side-channels and other floodplain habitats. There are also issues with low flows below the Oak Grove Reservoir to Three Lynx Creek. The highway also narrows the channel resulting in a decline in the quantity of habitat. North Fork Reservoir eliminated all spawning habitat in the lower portion of this area. However, it also greatly increased the amount of potential rearing habitat for juvenile salmonid life stages. It is unclear how much spawning habitat was lost due to the reservoir because the dams inundated a fairly steep, confined canyon area that may have provided limited spawning potential. The three-dam complex operated by PGE that forms the downstream boundary of this area also forms and Obstruction and decreases survival of adult and juvenile migrants.

Restoration Hypotheses and Strategies

Fish Passage Obstructions

The greatest restoration value for coho in the upper Clackamas Basin lies in the Middle Clackamas area, largely a function of mortality associated with the PGE dam complex and reservoir. The dam complex also impacts spring Chinook salmon and Upper Clackamas winter steelhead.

Hypothesis 21: ***Improving fish passage mortality at the PGE dams will increase survival for the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 21.1. Improve fish passage at the PGE dams.

Side Channels and other Floodplain Habitats

Confinement of the Middle Clackamas River channel, loss of large wood, and modified riparian areas has contributed to the loss of side-channel and other habitats. Slow water habitats, such as side channels, alcoves and the margins of complex wood jams, provide a diverse array of water depths and velocities, which provide cover for adult fish and rearing and refuge areas for juveniles.

Hypothesis 22: ***Restoring historic channel structure, side-channels and other complex habitats in the Middle Clackamas River will improve survival for the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants, spawning, and juvenile rearing and migrant.***

Action 22.1. Reconnect historic side channels within and along the Middle Clackamas River.

Large Wood

Processes that transport and deliver large wood to the Middle Clackamas River have been altered by modified riparian areas, removal of wood, and channel confinement. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., retention behind dams). Large wood in the river channel, alcoves, and side channels, provide complex habitats and low water velocities, which contributes to improved areas for spring chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered in sections along the Upper Clackamas River. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river.

Hypothesis 23: ***Increased large wood in the Middle Clackamas River channel and backwater areas and improved riparian conditions, width and***

connectivity will increase survival for the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants, spawning, and juvenile rearing and migrant.

Action 23.1. Add large wood to the Middle Clackamas River channel and existing backwater habitats as individual pieces and in large logjams.

Action 23.2. Restore floodplain and riparian vegetation, particularly to accelerate late-successional forest structure along the Middle Clackamas River.

Protection Hypotheses and Strategies

There is high quality riparian and aquatic habitat within and along the Middle Clackamas River. Ongoing habitat protection will assure that important habitats are not lost and help maintain processes that support and maintain complex habitat features.

Hypothesis 24: ***Protecting high quality floodplain, side-channel, and other riparian habitats, in association with restoration actions to increase habitat area and connectivity along the Middle Clackamas River will increase survival for the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Action 24.1. Protect high quality floodplain and riparian habitats along the Middle Clackamas River.

Fish Creek

Protection Priority: 12

Restoration Priority: 13

Fish Creek is a tributary entering the Clackamas River at about RM 41.5. The creek has a low overall Protection priority (12 of 15) and Restoration priority (13 of 15). Three of the six populations are potentially directly affected by conditions in Fish Creek. The area also received a low ranking for Protection and Restoration for coho, chinook and steelhead.

Figure 36. Protection and restoration rankings for the Fish Creek area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Fish Creek

Population	Area Rank			Survival Factor Priority for Restoration															
	Protection Rank	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho																			
Upper Coho	7	6	9	•				•	•	⬤						●	•		•
Lower Steelhead																			
Upper Steelhead	5	7	8					•		•					•	●	•		•
Fall Chinook																			
Spring Chinook	10	9	13	•				•	•	•						●	●		•
Average Area Rank	7.3	7.3	10.0																

Limiting Factors

Restoration priorities include Sediment, Temperature and Habitat Diversity. These factors can be largely traced to logging and road building activities in the watershed. There has been extensive harvest and associated road-building activity in the Fish Creek Watershed. Over the past several decades, the Forest Service has pursued extensive road, riparian, and in-channel restoration actions. Increased water temperatures and sediment deposition are key factors impacting winter steelhead survival.

Restoration Hypotheses and Strategies

Water Temperature

Increased water temperatures during the summer and early fall have impacted fish populations.

Hypothesis 25: ***Improved canopy cover over stream channels will improve summer and early fall water temperatures, increasing survival for juvenile winter steelhead Fish Creek and tributaries.***

Strategy 25.1. Improve water temperatures by increasing canopy cover over Fish Creek and tributaries.

Sediment

Sediment deposition is impacting spawning habitats, particularly for winter steelhead.

Hypothesis 26: ***Reducing sediment transport and delivery to stream channels will improve spawning habitat condition and improve survival for winter steelhead in Fish Creek and tributaries.***

Action 26.1. Reduce sediment delivery to stream channels from roads through the application of appropriate BMPs along Fish Creek and tributaries.

Roaring River

Protection Priority: 13

Restoration Priority: 14

Roaring River enters the middle Clackamas River about RM 44. Much of the watershed is inaccessible to anadromous fish due to a natural barrier about three miles from the mouth. The accessible portion of the river is a narrow, steep-sided gorge. The Roaring River area received nearly the lowest Protection (13 of 15) and Restoration (14 of 15) rankings in the Clackamas River across all six populations. Conditions in the Roaring River affect three of the six populations. The area received low rankings for Protection and Restoration for the three individual populations (Figure 36).

Limiting Factors

The low rankings for Roaring River are because the accessible length of the stream is quite small (about three miles) and the accessible portion is a high gradient, naturally confined canyon. The area does have decreased Habitat Diversity (lack of large wood) and increased levels of fine sediment (Figure 36).

Figure 36. Protection and restoration rankings for Roaring River area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Roaring River

Population	Area Rank: Protection Rank	Area Rank: Restoration Rank	Area Rank: Out of	Survival Factor Priority for Restoration: Channel stability/landsc.1/	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Lower Coho																			
Upper Coho	8	8	9	•				•	•	⬤						●			●
Lower Steelhead																			
Upper Steelhead	7	8	8					•		•						●			●
Fall Chinook																			
Spring Chinook	9	9	13							•						•			●
Average Area Rank	8.0	8.3	10.0																

Large Wood

Processes that transport and deliver large wood to the Roaring River have been altered through modified riparian areas, removal of wood, and channel confinement. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., where there are river-side roads). Large wood in the stream and tributaries provide complex habitats and low water velocities, which contributes to improved areas for spring chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered in sections along Roaring River. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river.

Hypothesis 27: ***Increased large wood in Roaring River and improved riparian conditions, including width and connectivity will increase survival for coho and spring chinook salmon, and winter steelhead life stages.***

Strategy 27.1. Add large wood to Roaring River as individual pieces and in large logjams.

Strategy 27.2. Restore floodplain and riparian vegetation along Roaring River.

Sediment

Sediment deposition is impacting spawning habitats.

Hypothesis 28: ***Reducing sediment transport and delivery to Roaring River and tributary stream channels will improve spawning habitat condition and improve survival for winter steelhead and coho salmon.***

Strategy 28.1. Reduce sediment delivery to stream channels from roads and development through the application of appropriate BMPs along Roaring River and tributaries.

Middle Clackamas Tributaries

Protection Priority: 11
Restoration Priority: 15

This area consists of the smaller tributaries in the area between North Fork Dam and Oak Grove Fork include the North Fork Clackamas, South Fork Clackamas, and Sandstone, Big, Whale and Cripple creeks. Overall, these tributaries ranked low for both Protection and Restoration. For the Clackamas River as a whole, these tributaries were ranked 11 (out of 15) for Protection and 15 (out of 15) for restoration. Conditions in these tributaries potentially affect three of the six populations. For the individual populations they ranked moderately low for protection but nearly last for restoration.

Limiting Factors

Increased fine sediment was a limiting factor for all species. Most of these tributaries are within watersheds that have recent or active logging and associated road building. Obstructions that limit fish movement are an important limiting factor for steelhead in these tributaries. Sediment, Habitat Diversity and Key Habitat Quantity are also degraded, all of which reflect logging and road building in the watersheds.

Restoration Hypotheses and Strategies

Figure 37. Protection and restoration rankings for the Middle Clackamas Tributaries area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Middle Clackamas Tributaries

Population	Area Rank			Survival Factor Priority for Restoration															
	Protection Rank	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho																			
Upper Coho	5	9	9					•		●						●			•
Lower Steelhead																			
Upper Steelhead	6	7	8					•		•		⬤				●			•
Fall Chinook																			
Spring Chinook	11	11	13					•		•						●			•
Average Area Rank	7.3	9.0	10.0																

Sediment

Sediment deposition is impacting spawning habitats.

Hypothesis 29: ***Reducing sediment transport and delivery to stream channels will improve spawning habitat condition and improve survival for winter steelhead, coho salmon, and spring Chinook salmon in Middle Clackamas tributaries.***

Strategy 29.1. Reduce sediment delivery to stream channels from roads, agricultural practices, and development through the application of appropriate BMPs.

Fish Passage Obstructions

Fish passage obstructions limit access to spawning and rearing areas for winter steelhead

Hypothesis 30: ***Improving fish passage at road crossing culverts will increase habitat quantity and improve survival for Upper Clackamas River adult spawning and juvenile winter steelhead in the Middle Clackamas tributaries.***

Strategy 30.1: Improve fish passage at identified fish passage barriers at road crossing culverts and other obstructions in the Middle Clackamas tributaries.

Upper Clackamas River

Overall Protection Priority: 2

Overall Restoration Priority: 8

The Upper Clackamas River area is the mainstem of the Clackamas River from Oak Grove Fork to headwaters. This portion of the river is a key spawning and rearing area for the Upper Clackamas coho salmon and winter steelhead populations and it provides important habitat for spring chinook salmon as well. The area includes the Big Bottom, which is generally considered the highest quality coho salmon habitat in the Clackamas River Subbasin.

Conditions in the upper Clackamas mainstem are generally good to excellent. The area ranked number two for Protection priority for the whole of the Clackamas River across all six populations. The upper mainstem had a moderate overall rank for Restoration (8 of 15). The area benefits three of the six populations and received the number one rank for Protection for each population (Figure 38). Restoration priority was moderately high for coho (3 of 9) and spring chinook (4 of 13) and moderate for steelhead (4 of 8).

Limiting Factors

Habitat limitation for salmon in the upper Clackamas mainstem include loss of Habitat Diversity (decline in large wood and decreased riparian forests), Harassment (proximity of human activities to salmon), increased Sediment and decline in the quantity of Key Habitat types. Riparian forests have been decreased due to highway construction along the river; many areas have stands of young and deciduous trees which provide inferior instream wood other riparian benefits. Sediment in the upper river has increased due to logging and road building (USFS 1995). The quantity of Key Habitats for various salmonid life stages has decreased due to narrowing and straightening of the channel because of the highway that parallels much of the upper river. This has also decreased river side channels and simplified the channel structure.

Figure 38. Protection and restoration rankings for the Upper Clackamas area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Upper Clackamas

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho																			
Upper Coho	1	3	9					•		●	•					•			•
Lower Steelhead																			
Upper Steelhead	1	4	8							•	•				•	●			•
Fall Chinook																			
Spring Chinook	1	4	13							•	•					•			•
Average Area Rank	1.0	3.7	10.0																

Restoration Hypotheses and Strategies

Side-Channels and Other Floodplain Habitats

Confinement of the Upper Clackamas River channel, loss of large wood, and modified riparian areas has contributed to the loss of side-channel and other habitats. Slow water habitats, such as side channels, alcoves and the margins of complex wood jams, provide a diverse array of water depths and velocities, which provide cover for adult fish and rearing and refuge areas for juveniles.

Hypothesis 31: ***Restoring historic channel structure, side-channels and other complex habitats in the Upper Clackamas River will improve survival for pre-the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 31.1. Reconnect historic side channels and floodplain connectivity within and along the upper Clackamas River.

Large Wood

Processes that transport and deliver large wood to the Upper Clackamas River have been altered through modified riparian areas, removal of wood, and channel confinement. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., where there are river-side roads). Large wood in the river channel, alcoves, and side channels, provide complex habitats and low water velocities, which contributes to improved areas for spring chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered in sections along the Upper Clackamas River. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river.

Hypothesis 32: ***Increased large wood in the Upper Clackamas River channel and side-channels and other habitat areas and improved riparian conditions, including width and connectivity and increased late-successional forest structures will increase survival for the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 32.1. Add large wood to the Upper Clackamas River channel and existing backwater habitats as individual pieces and in large logjams.

Strategy 32.1. Restore floodplain and riparian vegetation along the Upper Clackamas River, particularly to accelerate late-successional forest structure.

Protection Hypotheses and Strategies

The foremost habitat priority in the upper Clackamas River is protection. This area has a high quality habitat for chinook, coho and steelhead. Much of it is within federal ownership in the Mt. Hood National Forest. Protection is needed, however, from the impacts of logging, recreation and other activities within the national forest.

Hypothesis 34: ***Protecting high quality floodplain, side-channel, and other riparian habitats, in association with restoration actions to increase habitat area and connectivity along the Upper Clackamas River will increase the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 34.1: Protect high quality floodplain, and riparian habitats along the Upper Clackamas River.

Strategy 34.2: Protect upriver tributary watersheds from negative effects of logging and road building by ensuring the use of Best Management Practices and restricting logging in riparian areas (unless required to required to accelerated late-successional conditions).

Collowash River

Overall Protection Priority: 4

Overall Restoration Priority: 10

The Collowash River is the largest tributary in the upper Clackamas River. The Collowash River watershed is managed by the Forest Service and contains areas with high quality riparian and stream habitats. Upper parts of the watershed are in the Bull of the Woods Wilderness Area. While the area does not support large numbers of spawning and rearing fish, it does provide diverse habitats, primarily for coho salmon and winter steelhead.

The Collowash ranked fourth (of 15) in overall Protection priority within the Clackamas River and 10^{th} (of 15) in regard to Restoration. The river provides benefits to three of the six populations in the Clackamas River. It is especially important to winter steelhead in the upper basin and ranked second (of 8) in regard to Protection. Restoration priorities for all three populations were moderately low (Figure 39).

Potential of the habitat in the Collowash is primarily limited by Obstructions which are culverts under logging and other roads (Figure 39). There is some increase in sediment as a result of roads and logging. Roads and logging has also narrowed the channel in places and decreased the quantity of Key Habitat. Habitat Diversity has decreased with a primary impact on juvenile rearing for coho salmon. This is the result of some decrease in riparian forest and a decline in large wood deliver to the stream.

Figure 39. Protection and restoration rankings for the Collowash River area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Collowash River

Population	Area Rank			Survival Factor Priority for Restoration															
	Protection Rank	Restoration Rank	Out of	Channel stability/landsc.1/	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Lower Coho																			
Upper Coho	4	5	9							⬤		●				●			•
Lower Steelhead																			
Upper Steelhead	2	5	8									●				●			•
Fall Chinook																			
Spring Chinook	4	8	13													•			•
Average Area Rank	3.3	6.0	10.0																

Restoration Hypotheses and Strategies

Fish Passage Obstructions

Obstructions (culverts) are key factors in the upper Clackamas Subbasin. The smaller tributaries to the Collowash River had some culverts with varying degrees of passage.

Hypothesis 35: ***Improving fish passage at road crossing culverts in the Collowash Watershed will increase habitat quantity and improve survival for Upper Clackamas River coho salmon and winter steelhead.***

Action 35.1. Improve fish passage at road crossing culverts on tributaries to the Collowash River.

Large Wood

Processes that transport and deliver large wood to the portions of the Collowash River and some tributaries have been altered through modified riparian areas, removal of wood, and channel confinement. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., where there are river-side roads). Large wood in the river channel, alcoves, and side channels, provide complex habitats and low water velocities, which contributes to improved areas for spring chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered in sections along the Collowash River and tributaries. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river.

Hypothesis 36: ***Increased large wood in the Collowash River channel and side-channels and tributaries and improved riparian conditions, including width and connectivity and increased late-successional forest structures will increase survival for the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 36.1. In areas that are identified to be deficient in large wood, add large wood to the Collowash River and tributary channels as individual pieces and in large logjams.

Strategy 36.2. Restore floodplain and riparian vegetation along the Collowash River and tributaries, particularly to accelerate late-successional forest structure.

Protection Hypotheses and Strategies

There is high quality riparian and aquatic habitat within and along the Collowash River and tributaries. Ongoing habitat protection by the Forest Service will assure that important habitats are not lost and help maintain processes that support and maintain complex habitat features.

Hypothesis 37: ***Protecting high quality floodplain, side-channel, and other riparian habitats, in association with restoration actions to increase habitat area and connectivity in the Collowash River Watershed will increase the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 37.1. Protect high quality floodplain, and riparian habitats Collowash River Watershed.

Hot Springs Fork

Overall Protection Priority: 9

Overall Restoration Priority: 11

Hot Springs Fork is the largest tributary to the Collowash River. The lower part of the watershed is in the Mt. Hood National Forest and the upper portion is in the Bull of the Woods Wilderness Area.

Although habitat in the Hot Springs Fork is of high quality, the stream has only moderate protection and restoration rankings for the Clackamas River as a whole. Conditions in the Hot Spring Fork potentially impact three of the six populations. The stream received moderately low Protection ranking for upriver coho (5 of 9) and a low ranking for Restoration (7 of 9). The Hot Springs Fork has a relatively high gradient (3%) and is more suited to steelhead than coho. However, rankings for steelhead and spring chinook were also moderately low (Figure 40). Overall, the Hot Springs ranked low in this assessment due to its relatively small size and the resulting low biological

Figure 40. Protection and restoration rankings for the Hot Springs Fork area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Hot Springs Fork

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho																			
Upper Coho	5	7	9					•		●		●				●			●
Lower Steelhead																			
Upper Steelhead	4	6	8					•		•		⬤				●			●
Fall Chinook																			
Spring Chinook	5	7	13							•		●				•			●
Average Area Rank	4.7	6.7	10.0																

capacity and its extreme upriver location and the resulting effects of all the habitat constraints below its confluence with the Collowash River.

Habitat constraints in the Hot Springs Fork were Obstructions, Habitat Diversity, Sediment and Key Habitat Quantity (Figure 40). Obstructions (culverts and road crossings) were a key limiting factor for winter steelhead that would use the upper reaches with better access. Less robust riparian forests and lack of large wood have decreased Habitat Diversity. Sediment reflects some logging and road building in the watershed while the stream has narrowed somewhat resulting in a loss of the quantity of Key Habitats.

Restoration Hypotheses and Strategies

Obstructions

There are some fish passage obstructions in the Hot Springs Fork watershed that are limiting winter steelhead spawning and rearing.

Hypothesis 38: ***Improving fish passage at road crossing culverts in the Hot Springs Fork will increase habitat quantity and improve survival for Upper Clackamas River adult and juvenile winter steelhead.***

Action 38.1. Improve fish passage at road crossing culverts on tributaries to the Hot Springs Fork.

Large Wood

Processes that transport and deliver large wood Hot Springs Fork have been altered through modified riparian areas, removal of wood, and channel confinement. In some areas, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., where there are stream-side roads). Large wood in the river channel, alcoves, and side channels, provide complex habitats and low water velocities, which contributes to improved areas for spring chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered in sections along the Hot Springs Fork and tributaries. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river and tributary channels.

Hypothesis 39: ***Increased large wood in the Hot Springs Fork and improved riparian conditions, including width and connectivity and increased late-successional forest structures will increase survival for the coho pre-spawning migrants, spawning adults, and rearing juveniles and spring chinook salmon juvenile rearing and migrant.***

Strategy 39.1. Where there are identified reduced large wood levels, add large wood to the Hot Springs Fork and tributary channels.

Strategy 39.2. Restore riparian vegetation along the Hot Springs Fork and tributaries, particularly to accelerate late-successional forest structure.

Protection Hypotheses and Strategies

There is high quality riparian and aquatic habitat within and along the Hot Springs Fork and tributaries. Ongoing habitat protection by the Forest Service will assure that important habitats are not lost and help maintain processes that support and maintain complex habitat features.

Hypothesis 40: ***Protecting high quality floodplain, side-channel, and other riparian habitats, in association with restoration actions to in the increase habitat area and connectivity in the Hot Springs Fork watershed will increase the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 40.1. Protect high quality floodplain, and riparian habitats Hot Springs Fork Watershed.

Upper Clackamas Tributaries

Protection Priority: 6

Restoration Priority: 9

This area consists of smaller tributaries in the Clackamas River above Oak Grove Fork including Tag, Trout, Pot, Wolf, Kansas, Pinhead, Last, Lowe Rhododendron, Fawn, Hunter, Cub and Berry creeks. This portion of the Clackamas Subbasin is managed by the Forest Service and contains areas with high quality riparian and stream habitats. While the area does not support large numbers of spawning and rearing fish, it does provide diverse habitats, primarily for coho salmon and winter steelhead.

The Upper Clackamas Tributaries had moderate overall restoration and protection rankings for the entire Clackamas River. The streams potentially affect three of the six populations. Relative to the small tributaries in the middle and lower Clackamas, the upper Clackamas tributaries were ranked high for the three relevant populations (Figure 41). For upriver coho, the tributaries were ranked number two (of 9) for Protection and were ranked number one for Restoration. For upriver winter steelhead, the tributaries were ranked number 2 (of 8) for both Protection and Restoration.

The primary habitat limitation in the upper Clackamas tributaries is Obstructions (Figure 41) that limit access to upper reaches by coho and steelhead. Increased levels of fine sediment and a decline in the quantity of habitat also limited potential performance.

Restoration Hypotheses and Strategies

Fish Passage Obstructions

Obstructions (culverts) are key factors in the upper Clackamas Subbasin. The smaller tributaries to the Clackamas had eleven culverts with varying degrees of fish passage obstructions.

Figure 41. Protection and restoration rankings for the Upper Clackamas Tributaries area and restoration effects of survival attributes on six populations from the Clackamas River.

Geographic Area: Upper Clackamas River Tributaries

	Area Rank			Survival Factor Priority for Restoration															
Population	**Protection Rank**	**Restoration Rank**	**Out of**	***Channel stability/landsc.1/***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Lower Coho																			
Upper Coho	2	1	9					•		●		⬤				●			●
Lower Steelhead																			
Upper Steelhead	2	2	8							•		⬤			•	●			●
Fall Chinook																			
Spring Chinook	3	5	13					•							•	•			●
Average Area Rank	2.3	2.7	10.0																

Hypothesis 41: ***Improving fish passage at road crossing culverts on Upper Clackamas Tributaries will increase habitat quantity and improve survival for Upper Clackamas River adult spawning and juvenile coho salmon and winter steelhead.***

Action 41.1. Improve fish passage at road crossing culverts on Upper Clackamas Tributaries.

Protection Hypotheses and Strategies

There is high quality riparian and aquatic habitat within and along Upper Clackamas Tributaries. Ongoing habitat protection by the Forest Service will assure that important habitats are not lost and help maintain processes that support and maintain complex habitat features.

Hypothesis 42: ***Protecting high quality riparian habitats, in association with restoration actions to increase habitat area and connectivity in Upper Clackamas River Tributaries will increase the following coho and spring chinook salmon, and winter steelhead life stages: Adult pre-spawning migrants and juvenile rearing and migrant.***

Strategy 42.1. Protect high quality floodplain, and riparian habitats along Upper Clackamas River Tributaries.

Analysis of Properly Functioning Conditions for Salmonid Populations in the Clackamas River

Description of PFC Conditions in EDT

Properly functioning conditions (PFC) is a concept created originally by the Bureau of Land Management (BLM) to assess the natural habitat-forming processes of riparian and wetland areas (Pritchard and others 1993). When these processes are working properly, it can be assumed that environmental conditions are suitable to support productive populations of native anadromous and resident fish species. The notion of Properly Functioning Conditions for salmonid systems has also been advanced by the National Marine Fisheries Service (1996) in connection with recovery of species listed under the Endangered Species Act.

The PFC concept has been translated into a set of EDT Level 2 attribute ratings—ratings that define a PFC environmental condition relevant to anadromous salmonids within Pacific Northwest streams. Following an assessment of current and template conditions, EDT was used to assess population performance for a third condition, PFC. The PFC scenario is not necessarily advocated by any management agency and has not been analyzed for feasibility. Instead, it is used to illustrate species performance under a set of conditions likely to be conducive to healthy fish populations.

PFC does not imply pristine or template conditions. There are many examples of healthy populations occupying degraded habitat (Hanford Reach Chinook, for example). With this in mind, PFC ratings were applied to all reaches regardless of current habitat ratings (e.g., if riparian function is 100% for the current condition, the PFC condition would still apply the 70% functional rating).

Also, PFC is not intended to imply a standard against which all streams are compared. PFC cannot be “better” than historic conditions for a stream reach (e.g., if percent fine sediment in historic reconstruction was 15%, the PFC rating for sediment must be greater than or equal to 15%).

We used Properly Functioning habitat conditions outlined by the National Marine Fisheries Service (1996) to help define the EDT PFC Level 2 ratings. The NMFS document includes a Matrix of Pathways and Indicators (MPI) that relates closely to EDT attributes. An inter-agency team organized by Washington Department of Fish and Wildlife and the Northwest Indian Fisheries Commission was responsible for translating the NMFS definitions into EDT Level 2 attributes. EDT attribute ratings and their relationship to the NMFS definition of PFC are presented in Table 1. However, NMFS has not, at this time, endorsed the EDT PFC definition in connection with recovery of listed fish populations. The MPI addressed only a subset of the attributes used in EDT. All attributes used in EDT were assigned a PFC condition by the inter-agency team.

Table 1 also includes those attributes that were not defined by NMFS but were assigned a PFC rating by the technical team. Our guidance for these attributes was an understanding of the intent of the NMFS definition of properly functioning gleaned largely from attributes described in the MPI.

The composition of habitat types (pool, riffle, glide, etc) was not clearly defined in the MPI for PFC. The MPI provided pool frequency by channel width (number of pools per mile). However, this description did not adequately consider differences in gradient and channel confinement between stream reaches. Furthermore, the pristine composition of habitat types is not consistent with the overall PFC definition. Simply applying the template assumptions to PFC is not appropriate.

The EDT definition of habitat types under PFC assumes 80% of the template or 80% of current (whichever is greater) pool type habitat (primary pools, backwater pools and pool tailouts, and beaver ponds) within the reach. The composition of non-pool habitat (riffles and glides) is calculated, using the template composition of these habitat types for the reach. This assumes that the template characterization for riffle and glide habitat (largely based on an assessment of channel gradient and confinement for the reach) would correctly represent the natural composition (i.e., derived through natural habitat-forming processes) for these habitat types.

National Marine Fisheries Service (NMFS). 1996. Making ESA determinations of effect for individual or grouped actions at the watershed scale. Environmental and Technical Services Division, Habitat Conservation Branch, Portland, Oregon

Prichard, D., H. Barrett, J. Cagney, R. Clark, J. Fogg, K. Gebhardt, P. Hansen, B. Mitchell, and D. Tippy. 1993. Riparian area management: process for assessing proper functioning condition. TR 1737-9. Bureau of Land Management, BLM/SC/ST-93/003+1737, Service Center, Co. 60 pp.

Table 1. Correspondence of Properly Functioning Condition as designated by NMFS (1996) and PFC as used in the EDT model.

Attribute	NMFS (1996) Properly Functioning Condition	Representation of PFC in EDT Level 2 Environmental Attribute
Hydrologic Characteristics		
1) Annual Variation in High Flow	a) Change in Peak/Base Flow: Watershed hydrograph indicates peak flow, base flow, and flow timing characteristics comparable to an undisturbed watershed of similar size, geology, and geography	Consistent with undisturbed watershed of similar size, geology, and geography (Rating 2).
2) Annual Variation in Low Flow		Consistent with natural runoff pattern or hydro project following WDFW ramping rate criteria (Rating 2).
3) Diel Variation in Flow		Consistent with undisturbed watershed of similar size, geology, and geography (Rating 1).
4) Intra-Annual Variation in Flow	b) Increase in Drainage Network: Zero or minimum increases in drainage network density due to roads.	Consistent with undisturbed watershed of similar size, geology, and geography (Rating 2).
5) Natural Hydrologic Regime	Not described	Attribute describes basic geomorphology and hydrology of basin
6) Regulated Hydrologic Regime	Not described	Flow not modified by hydro project (Rating 0)
Stream Corridor Structure		
7) Channel Length	Not described	EDT analysis assumed historic (template) channel length, gradient and widths; this assumption consistent with assumptions for channel hydromodifications (none)
8) Gradient		
9) Channel Minimum Width		
10) Channel Maximum Width		
11) Hydromodifications	Off-channel areas are frequently hydrologically linked to main channel; overbank flows and maintain wetland functions, riparian vegetation and succession	Stream channel is fully connected to the floodplain although very minor structures may exist that do not result in flow restriction or constriction (Rating 0).
12) Natural Channel Confinement	Not described; attribute describes basic geomorphology of reach	No difference between historic and current ratings in EDT
13) Habitat Types	a) Pool Frequency: Width 5' 184 pools/mile Width 10' 96 pools/mile Width 15' 70 pools/mile Width 20' 56 pools/mile Width 50' 26 pools/mile Width 75' 23 pools/mile Width 100' 18 pools/mile b) Pool Quality: Pools > 1 meter depth (holding pools) with good cover and cool	Assumed to be consistent with 80% of historic (template) pool frequency; EDT criteria developed to acknowledge reach-specific differences in pool frequency.

Attribute	NMFS (1996) Properly Functioning Condition	Representation of PFC in EDT Level 2 Environmental Attribute
	water, minor reduction of pool volume by fine sediment	
14) Habitat Type – Off Channel	Backwaters with cover, and low-energy off-channel areas (ponds, oxbows, etc.)	Assumed full connection of historic (template) off-channel habitats.
15) Migration Obstructions	Any man-made barriers present in watershed allow upstream and downstream fish passage at all flows	Obstructions removed or designed to allow full passage of juveniles and adults (Rating 0)

Attribute	NMFS (1996) Properly Functioning Condition	Representation of PFC in EDT Level 2 Environmental Attribute
16) Water withdrawals	Not described	Very minor withdrawals (entrainment probability considered to be very low)
17) Bed Scour	Although not described, bank stability - >90% of banks not actively eroding - implies a stable stream bed.	Average depth of scour >2 cm and < 10 cm (Rating 1)
18) Icing	Not described	Riparian function is high, assumed no degradation of channel stability due to icing – assume historic (template) condition
19) Riparian Function	The riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and buffers include known refugia for sensitive aquatic species (>80% intact); and/or grazing impacts; percent similarity of riparian vegetation to the potential natural community composition > 50%.	> 70%-90% of functional attributes present (overbank flows, vegetated streambanks, groundwater interactions typically present) (modeled 70% - Rating 1.6).
20) Wood Debris	>80 pieces/mile (diameter > 2"; length > 50') and adequate sources of woody debris recruitment in riparian areas.	Complex array of large wood pieces but fewer cross channel bars and fewer pieces of sound large wood due to reduced recruitment; influences of large wood and jams are a prevalent influence on channel morphology where channel gradient and flow allow such influences. (Rating 1).
21) Embeddedness	Dominant substrate is cobble or gravel, or embeddedness < 20%	>10% and <25% covered by fine sediment (Rating 1)
22) Fine Sediment (< 0.85 mm) and Turbidity	Fines: < 12%; turbidity low	Fines: 6%-11% (modeled 11% fines - Rating 1.5). Turbidity low, infrequent episodes, short duration, low concentrations (<50 mg/l) (Rating 0.5)
Water Quality		
23) Alkalinity and Dissolved Oxygen	Not described	Assumed historic (template) conditions
24) Pollutants (Metals, misc. pollutants)	Low levels of chemical contamination from agricultural, industrial and other sources, no excess nutrients, no CWA 303d designated reaches	No toxicity expected due to dissolved heavy metals to salmonids under prolonged exposure (1 month exposure assumed) (Rating 0.5).
25) Nutrient enrichment		Very small amount suspected through land use activities (Rating 1.5)
26) Temperature – Daily Maximum	10-14 C	10-16 C on warmest day (Rating 1)
27) Temperature – Daily Minimum	Not described	Assumed historic (template) conditions

Attribute	NMFS (1996) Properly Functioning Condition	Representation of PFC in EDT Level 2 Environmental Attribute
28) Temperature – Spatial Variation	Not described	Assumed historic (template) conditions

Attribute	NMFS (1996) Properly Functioning Condition	Representation of PFC in EDT Level 2 Environmental Attribute
Biological Community		
28) Biological community (benthic community richness, introduced species, predator risk, and fish community richness)	Not Described	Assumed historic (template) conditions
29) Fish Pathogens	Not Described	a) No fish stocking within last decade; or b) no sockeye population in basin; or c) no viral epizootics in kokanee populations at the subbasin level (Rating 1).
30) Salmon Carcasses	Not Described	Very abundant -- an average number of carcasses per total miles of main channel habitat >400 and < 800 (Rating 1.5).
22) Hatchery Outplants	Not Described	No more than two instances of fish releases in the past decade in the drainage (Rating 1.5).

Application of PFC conditions to the Clackamas River

The PFC conditions in Table 1 were applied to the Clackamas River and analyzed with EDT for the six defined populations. As described above, PFC conditions are generally an improvement over current conditions but always less than the template condition. Application of the PFC restored a substantial portion of the estimated potential of the four populations in the Clackamas River. PFC produced 81 percent of the potential for lower Clackamas winter steelhead (Figure 1), 83 percent of the potential for upper Clackamas winter steelhead (Figure 2), 67 percent of the potential for lower Clackamas coho (Figure 3), 79 percent of the potential for upper Clackamas coho (Figure 4), 74 percent of the potential for spring Chinook (Figure 5) and 71 percent of the potential for fall Chinook (Figure 6). PFC produced a Diversity Index similar to the template for all six populations.

Figure 1. Estimated potential of the Clackamas River for Lower Clackamas Winter Steelhead Trout under three scenarios.

Lower Clackamas Winter Steelhead Trout

Scenario	Diversity index	Productivity	Abundance
Current without harvest	43%	2.4	833
PFC Scenario	93%	14.5	4,154
Reference potential	93%	20.9	5,132

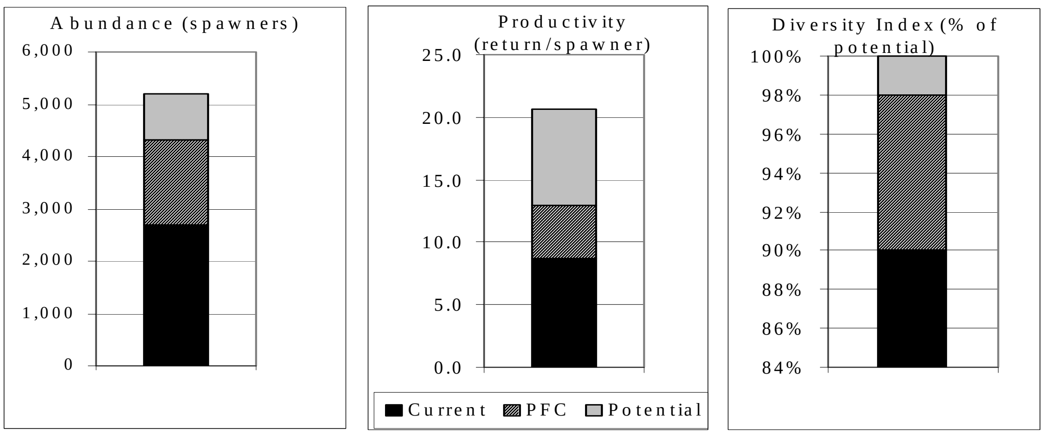


Figure 2. Estimated potential of the Clackamas River for Upper Clackamas Winter Steelhead Trout under three scenarios.

Upper Clackamas Winter Steelhead Trout

Scenario	Diversity index	Productivity	Abundance
Current without harvest	90%	8.7	2,693
PFC Scenario	98%	12.9	4,319
Reference potential	100%	20.6	5,208

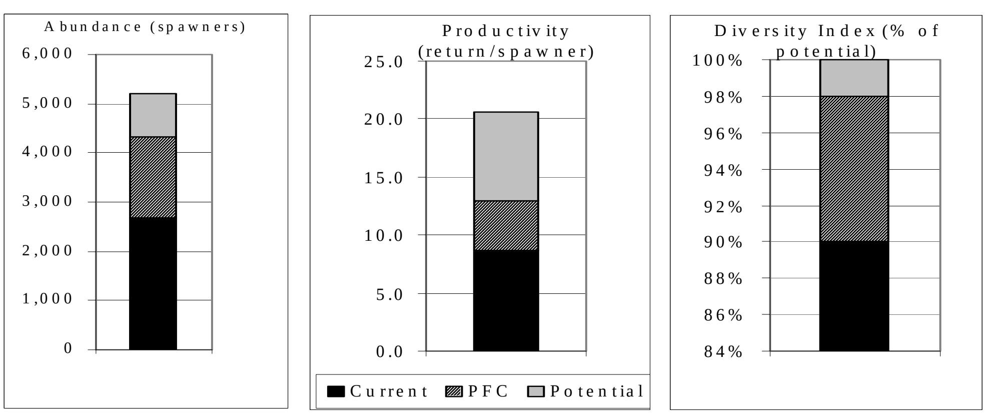


Figure 3. Estimated potential of the Clackamas River for Lower Clackamas Coho Salmon under three scenarios.

Lower Clackamas Coho Salmon

Scenario	Diversity index	Productivity	Abundance
Current without harvest	41%	1.8	705
PFC Scenario	93%	8.7	5,512
Reference potential	99%	13.4	8,262

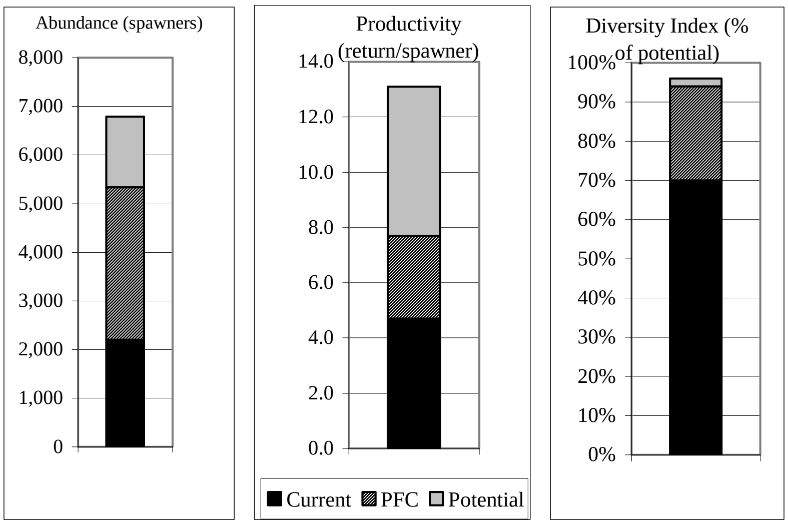


Figure 4. Estimated potential of the Clackamas River for Upper Clackamas Coho Salmon under three scenarios.

Upper Clackamas Coho Salmon

Scenario	Diversity index	Productivity	Abundance
Current without harvest	70%	4.7	2,202
PFC Scenario	94%	7.7	5,337
Reference potential	96%	13.1	6,785

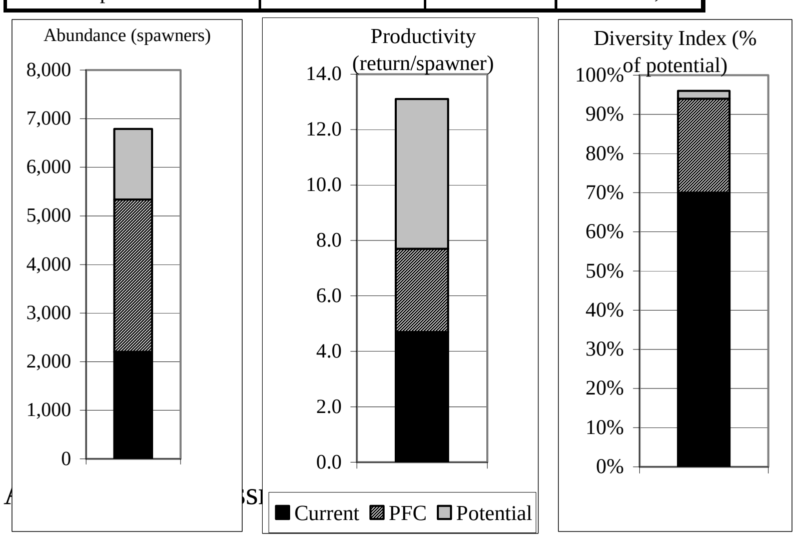


Figure 5. Estimated potential of the Clackamas River for Clackamas Spring Chinook Salmon under three scenarios.

Clackamas Spring Chinook Salmon

Scenario	Diversity index	Productivity	Abundance
Current without harvest	76%	4.7	2,434
PFC Scenario	100%	11.2	7,980
Reference potential	96%	17.9	10,716

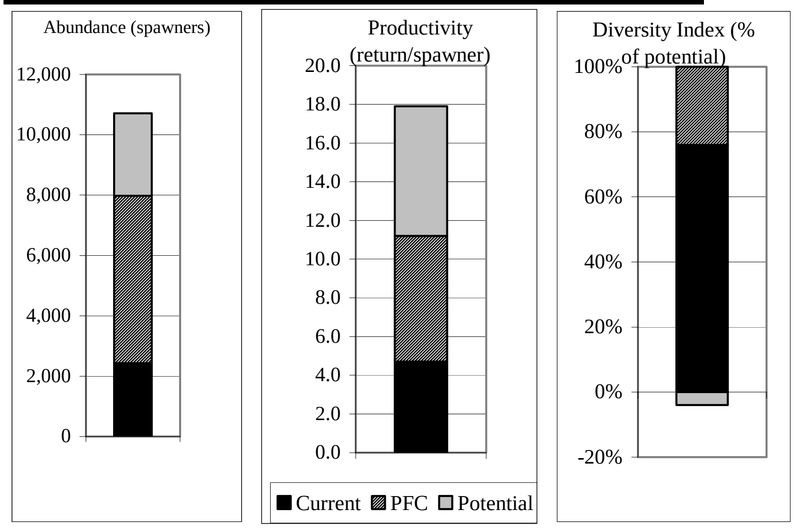
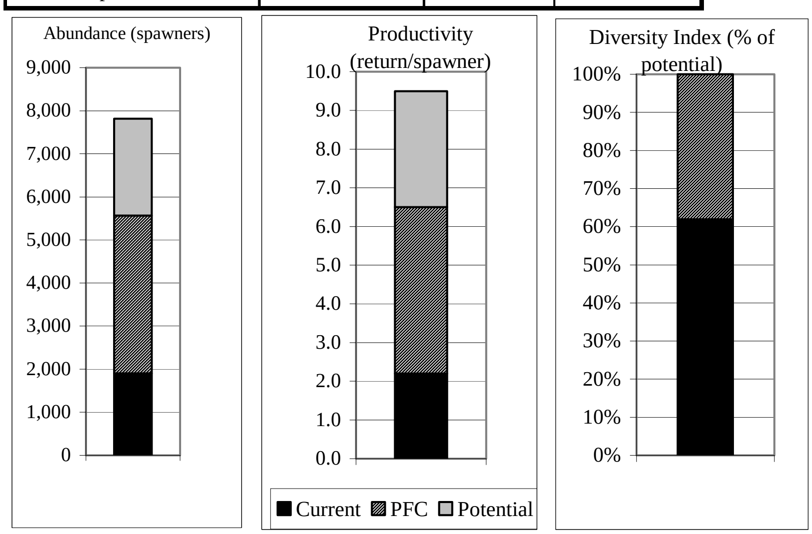


Figure 6. Estimated potential of the Clackamas River for Clackamas Fall Chinook Salmon under three scenarios.

Clackamas Fall Chinook Salmon

Scenario	Diversity index	Productivity	Abundance
Current without harvest	62%	2.2	1,904
PFC Scenario	100%	6.5	5,563
Reference potential	100%	9.5	7,816



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