3. Stresses and Threats

In 1997, NMFS listed the SONCC coho salmon ESU as threatened (62 FR 24588, May 6, 1997). In the final rule, NMFS summarized the status of coho salmon based on the five listing factors identified in section 4(a)(1) of the ESA, and described for each factor the associated stressors and threats. In 2005, NMFS reaffirmed the threatened status of SONCC coho salmon (70 FR 37160, June 28, 2005). The final rule for the latter decision, included the biological review team's (BRT) assessment of population- and ESU-level extinction risk utilizing the four viable salmonid population (VSP) parameters (McElhany et al. 2000) including abundance, population productivity, spatial structure, and diversity. The BRT concluded that "these four parameters are universal indicators of species viability, and individually and collectively function as reasonable predictors of extinction risk," including SONCC coho salmon.

This chapter describes, relative to the five listing factors, the past and present natural and anthropogenic activities that continue to contribute to physical and biological degradation of coho salmon habitat and ESU-wide population reductions. Ongoing anthropogenic activities—and future natural events or anthropogenic activities—determined to affect one or more coho salmon life stage are termed threats. The resultant physical or biological (or combination of both) responses to these threats are considered stresses or limiting factors. Any plans, programs or other mechanisms that are expected to alleviate a threat are discussed as part of the evaluation of the current status of threats. These vary from local watershed restoration plans to regional conservation strategies. Listing factors (via stresses and threats) are addressed and described for each population in the population profiles (Volume II). Table 3-1, Table 3-2, and Table 3-3 display the relationship between listing factors, threats and stresses that resulted in the current ESU-wide status of SONCC coho salmon.

Table 3-1. Relationship between listing factors, stressors and resultant threats for the ESU-wide status of SONCC coho salmon.

Threat	Listing Factor				
	Habitat Destruction, Modification or Curtailment	Over-Utilization for Commercial, Recreational, Scientific, or Educational Purposes	Disease and Predation	Inadequate Regulatory Mechanisms	Other Natural and Man-made Factors
Roads	X[a]			X	
Timber Harvest	X			X	
Channelization/Diking	X			X	
Agricultural Practices	X		X	X	
Dams/Diversions	X		X	X	
Mining/Gravel Extraction	X		X	X	
Urbanization	X		X	X	
Fishing and Collecting		X		X	
Climate Change			X	X	X
Hatcheries				X	X
Fire	X			X	
Invasive/Non-native Alien Species	X		X	X	

[a] Indicates a stress resulting from a threat

Table 3-2. Matrix of interrelated threats and stresses in the SONCC coho salmon ESU.

Threats	Stresses									
	Adverse Hatchery-Related Effects	Impaired Water Quality	Degraded Riparian Forest Conditions	Increased Disease/ Predation/ Competition	Altered Sediment Supply	Lack of Floodplain and Channel Structure	Altered Hydrologic Function	Barriers	Adverse Fishery-Related Effects	Impaired Estuary/ Mainstem function
Climate Change		X	X	X			X			X
Roads		X	X		X	X	X	X		X
Channelization/Diking		X	X		X	X	X			X
Agricultural Practices		X	X		X	X	X	X		X
Timber Harvest		X	X		X	X	X	X		X
Urban/Residential/ Industrial Development		X	X		X	X	X	X		X
High Intensity Fire		X	X		X		X			
Mining/Gravel Extraction		X	X		X	X	X	X		X
Dams/Diversions		X	X	X	X	X	X	X		X
Fishing and Collecting									X	
Invasive/Non-Native/Alien Species				X						X
Hatcheries	X			X						

Table 3-3. Threats at the time of listing as compared to current threats and stresses as identified in the SONCC coho salmon recovery plan.

Threat or stress		Threats identified at the time of listing.												
		Logging	Road Building	Grazing and Mining Activities	Urbanization	Stream Channelization	Dams	Wetland Loss	Beaver Trapping	Water Withdrawals	Unscreened Diversions	Overfishing in non-tribal fisheries	Natural Factors (Drought/floods)	Artificial Propagation
Threats														
	Roads	X	X		X	X		X						
	Timber Harvest	X	X				X	X	x					
	Channelization/Diking			x		X								
	Agricultural practices			X			X		X	X	X			
	Dams/Diversions			X			X	X	X					
	Mining/Gravel Extraction			X		X								
	Urbanization				X			X	X					
	Fishing and Collecting											X		X
	Climate Change												X	
	Hatcheries											X		X
	Fire				X									
	Invasive/Non-native Alien Species				X		X							
Stresses														
	Adverse Hatchery Related Effects													X
	Impaired Water Quality	X	X	X	X		X	X	X	X	X			
	Degraded Riparian Forest	X	X	X	X	X		X	X					
	Increased Disease/Predation/Competition				X		X			X				X
	Altered Sediment Supply	X	X	X	X	X	X	X					X	
	Lack of Floodplain and Channel Structure		X	X	X	X		X	X					
	Altered Hydologic Function	X	X	X	X	X	X	X	X					
	Barriers			X	X	X	X			X				
	Impaired Mainstem/Estuary Function	X	X	X	x	X	X	x	X	X			x	
	Adverse Fishery related Effects											X		X

NMFS assessed the viability of individual populations within the SONCC coho salmon ESU and the current condition of their habitats using five steps: (1) identify conservation targets; (2) assess population viability; (3) identify potential threats and stresses; (4) compile available literature, data and best professional knowledge on the condition of the landscape; and (5)

determine the severity and impact of stresses and threats affecting each population. This methodology is detailed in Appendix B.

Stresses are related to habitat conditions that resulted directly or indirectly from past anthropogenic activities and natural phenomenon, while threats are the sources of these stresses and are the expected potential for future stresses. Most stresses are due to anthropogenic uses of land, water and natural resources, and sometimes these activities indirectly cause stress to populations by exacerbating natural processes (e.g., increasing the rate of landslides). A threat is the proximate cause of a stress and is typically generated by human land use. The stresses and threats considered in the assessment are either current stresses, or have high potential to occur in the next 10 years under current circumstances and management (Appendix B). In addition to those stresses identified at the time of listing, additional stresses that are currently affecting SONCC coho salmon were identified and ranked using the CAP workbook for each life stage of coho salmon.

In addition to the CAP assessment process, NMFS used the best available science regarding the impacts of predicted shifts in climate, effects from fishing and collecting activities, and estuary and mainstem condition on the ability of the species' to recover. Additional categories (either stresses or threats) were created for *Climate Change*, *Impaired Estuary/Mainstem Function*, and *Fishing and Collecting*. Information regarding the severity of these threats, and the stresses they create in each population, can be found in Volume II of this Recovery Plan. The threat posed by climate change was considered when developing and recommending each recovery strategy, and when developing recommended recovery actions. Recommended recovery actions to address changing marine environmental conditions are included within recovery actions designed to support other objectives.

3.1 Stresses (Limiting Factors)

In each population profile we summarize and rank the stresses (limiting factors) and threats (Volume II). Each stress (limiting factor) assessment includes a summary table of the stress (limiting factor) rankings by coho salmon life stage, the overall stress (limiting factor) ranking, and a narrative discussing the effects on the population. In addition to the stresses (limiting factors) identified during listing, we performed a stress (limiting factor) ranking and assessment for *Impaired Estuary/Mainstem Function*. Whenever available, empirical data were used to populate the summary tables and CAP tables, and were used in the stress (limiting factor) assessment. Where this information was not available, NMFS staff relied on best professional judgment to assign a severity ranking to each stress (limiting factor) by life stage. Refer to Appendix B for more-detailed information on the methodologies used. Stresses (limiting factors) are listed in Table 3-4.

Table 3-4. Stress (limiting factor) severity ranking by population. Stress ranking represent CAP results as follows: L = Low, M = Medium, H = High, VH = Very High. See Appendix B for definition of severity rankings.

Stresses (Limiting Factors)											
Population	Adverse Hatchery Related Effects	Impaired Water Quality	Degraded Riparian Forest	Increased Disease/Predation/ Competition	Altered Sediment Supply	Lack of Floodplain and Channel Structure	Altered Hydrologic Function	Barriers	Impaired Mainstem/Estuary Function	Adverse Fishery related Effects	Total High or Very High
Elk River	L	H[1]	H	L	M	VH[1]	H	M	M	L	4
Lower Rogue River	M	H[1]	H	L	H	H[1]	M	L	H	L	5
Chetco River	NA	H[1]	VH[1]	NA	M	H[1]	H[1]	L	H[1]	L	5
Winchuck River	NA	H[1]	H	NA	H	VH[1]	H	L	M	L	5
Hubbard Creek	NA	M	H[1]	NA	M	VH[1]	L	L	H	L	3
Brush Creek	NA	L	H[1]	NA	M	VH[1]	L	L	L	L	2
Mussel Creek	NA	L	VH[1]	NA	M	VH[1]	L	L	L	L	2
Hunter Creek	NA	H[1]	H[1]	NA	H	VH[1]	L	L	M	L	4
Pistol River	NA	H[1]	H[1]	NA	VH[1]	VH[1]	H	L	M	L	5
Smith River	L	H[1]	M	L	M	H[1]	L	H	H[1]	M	4
Lower Klamath River	M	M	H	M	VH[1]	VH[1]	H	M	H	M	5
Redwood Creek	L	VH[1]	H	NA	H	VH[1]	M	L	VH	M	5
Maple Creek/Big Lagoon	NA	L	M	L	H[1]	VH[1]	M	L	H	M	3
Little River	NA	M	H	NA	VH[1]	H[1]	M	M	M	M	3
Mad River	L	H[1]	H	M	H	H	M	L	H	M	5
Elk Creek	NA	M	H[1]	NA	M	M	M	L	M	M	1
Wilson Creek	NA	L	H[1]	NA	H	H[1]	M	L	M	M	3
Strawberry Creek	NA	M	M	NA	M	M	M	H[1]	H[1]	M	2
Norton/Widow White Creek	NA	M	VH[1]	NA	M	H[1]	M	M	L	M	2

Stresses (Limiting Factors)											
Population	Adverse Hatchery Related Effects	Impaired Water Quality	Degraded Riparian Forest	Increased Disease/Predation/ Competition	Altered Sediment Supply	Lack of Floodplain and Channel Structure	Altered Hydrologic Function	Barriers	Impaired Mainstem/Estuary Function	Adverse Fishery related Effects	Total High or Very High
Humboldt Bay tributaries	L	H	H	L	VH[1]	VH[1]	M	H	H[1]	M	6
Low. Eel/Van Duzen rivers	NA	H	H	H	VH[1]	H	L	L	H[1]	M	6
Bear River	NA	H	VH[1]	NA	H	VH[1]	L	L	H	M	5
Mattole River	NA	VH[1]	H	NA	H	H	VH[1]	L	H	M	6
Guthrie Creek	NA	M	M	NA	H[1]	M	L	L	M	M	1
Illinois River	M	H[1]	VH[1]	M	H	H[1]	VH[1]	H[1]	H	L	7
Mid. Rogue/Applegate Rivers	M	VH[1]	VH[1]	L	L	VH[1]	VH[1]	M[1]	H	L	5
Upper Rogue River	M	VH[1]	VH[1]	L	H	H[1]	VH[1]	H	H	L	7
Middle Klamath River	M	H[1]	M	H	H[1]	H[1]	H	H	H	M	7
Upper Klamath River	VH	H[1]	H	H	H	H	H	VH[1]	H	M	9
Salmon River	L	M[1]	M[1]	L	M	M[1]	M	L	M	M	0
Scott River	M	H	VH[1]	L	H	VH	VH[1]	L	VH	L	6
Shasta River	H	VH[1]	H	VH	M	VH[1]	VH	M	VH	L	7
South Fork Trinity River	M	H[1]	H	L	H[1]	H	H[1]	M	M	M	5
Lower Trinity River	H[1]	M	M	L	H	VH[1]	H[1]	M	L	M	4
Upper Trinity River	VH[1]	M	M	H	M	H	H[1]	H[1]	M	M	5
South Fork Eel River	L	H	H	H	VH[1]	VH[1]	H	H	M	M	6
Mainstem Eel River	NA	M	H	H	VH[1]	H[1]	M[1]	M	M	M	3
Mid. Fork Eel River	NA	M	H[1]	H	H[1]	M	M	M	M	M	2
Mid. Mainstem Eel River	L	H[1]	VH[1]	H	VH[1]	H	H	M	M	M	5
Upper Mainstem Eel River	L	H[1]	H	H	H	H	M	VH[1]	M	M	5

In the following subsection we summarize the stresses (limiting factors)existing within the SONCC coho salmon ESU, with a brief description of effects to coho salmon and their habitat associated with each stress. In addition, each population profile (Volume II) provides a detailed description of each stress (limiting factor) at the population level, and recovery strategy and actions recommended to achieve viability.

3.1.1 Adverse Hatchery-Related Effects

Potential problems associated with hatchery programs include genetic impacts on naturally reproducing wild populations, competition for prey resources and available habitat, disease transmission, predation of wild fish, difficulty in determining wild stock status due to incomplete marking of hatchery fish, depletion of wild stock to the demand for increases in brood stock, replacement rather than supplementation of wild stocks, and continued annual introduction of hatchery fish (Hindar et al. 1991, Steward and Bjornn 1990, Waples 1991). Simply put, the more hatchery fish released, the greater the natural populations are effected, and the longer that these effects will occur. Even if all the hatcheries in the ESU were to stop producing fish, legacy genetic effects from past hatchery practices would continue to impact wild fish populations for many generations to come. Additionally, hatchery effects are exacerbated when populations are at or below depensation levels, as many are in the SONCC coho salmon ESU. Adverse hatchery-related effects from the high production of hatchery salmonids are a high or very high stress (limiting factor) in three populations in the SONCC coho salmon ESU (Table 3-4).

Three artificial propagation programs are considered to be part of the ESU: the Cole Rivers Hatchery (Rogue River), Trinity River Hatchery, and Iron Gate Hatchery (Klamath River) coho salmon programs (70 FR 37160, June 28, 2005). These hatcheries produce not only coho salmon but also Chinook salmon and steelhead for release into the wild, further impacting native coho salmon populations. In 2004 to2008, Iron Gate and Trinity River hatcheries volitionally released an average of 570,000 yearling coho salmon (<20/lb) in March through May. Collectively, these three hatcheries release about 14,215,000 hatchery salmonids (coho salmon, Chinook salmon, and steelhead) into the Rogue, Trinity and Klamath rivers annually, with approximately 5.6 and 6 million fish coming from the Trinity River and Iron Gate hatcheries alone (ICF/Jones & Stokes 2010). Annual coho salmon production goals at the Cole Rivers, Trinity River, and Iron Gate hatcheries are 200,000, 500,000, and 75,000, respectively.

All three hatchery programs release smolts on site, use volunteers as brood stock, include unclipped fish as brood stock and use various combinations of fin clips to mark their production. The proportion of wild origin recruits used as brood stock varies by hatchery and year. The proportion of wild brood stock at Cole Rivers Hatchery over the years 1995 to 1998 ranged from 24 percent to 72 percent, while the proportion of wild brood stock at Iron Gate Hatchery from 1998 to 2004 ranged from 8.8 percent to 48.3 percent. The release strategy for Chinook salmon at Trinity River and Iron Gate hatcheries may result in competition for limited habitat during the late spring between hatchery fish and naturally produced coho salmon. The potential for adverse effects on natural coho salmon populations is highest in late spring when lower flows and higher water temperatures may increase competition for suitable rearing habitat (CDFG and NMFS 2001). Naturally produced coho salmon juveniles may be preyed on by hatchery steelhead that may be residualizing in the Klamath and Trinity Rivers below Iron Gate and Trinity River hatcheries. Additionally, residualization of hatchery steelhead and predation on naturally

produced salmon and steelhead fry has been demonstrated in the Trinity River (Naman 2008), representing a potential threat to natural salmon and steelhead populations. Good et al. (2005) noted that 80 percent of the coho returning to Iron Gate Hatchery in 2001 were clipped hatchery fish, although the significance of this observation is unclear because of the location of the hatchery at the upstream end of the anadromous corridor. Good et al. (2005) also noted that hatchery fish comprised from 63 percent to 86 percent of the total fish harvested in the Yurok tribal coho harvest between 1997 and 2000. Iron Gate Hatchery fish represented 8 percent or less of the harvest of hatchery fish, but Trinity River Hatchery fish accounted for 87 percent to 95 percent of hatchery fish harvested from 1998 to 2001, and 40 percent of the hatchery fish captured in 1997. Finally, Good et al. (2005) noted that between 1997 and 2002, hatchery fish constituted between 89 percent and 97 percent of the coho (adults plus grilse) returning to the Willow Creek weir in the lower Trinity River (Sinnen 2002). The information available indicates that the influence of the hatchery stocking program on the genetic fitness of wild coho populations in the Klamath and Trinity rivers is significant. Moreover, because the Klamath and Trinity watersheds represent a large proportion of spawning and rearing habitat in this ESU, it is concluded that hatchery impacts are significant at the ESU level.

In addition to the aforementioned hatcheries, the Mad River and Rowdy Creek hatcheries (in California) and the Elk River Hatchery (in Oregon) are located within the ESU and produce steelhead and Chinook salmon, which also interact with SONCC coho salmon. The ICF/Jones & Stokes (2010) reported that in March of 2004 through 2008, Mad River Hatchery released an average of 200,000 steelhead yearlings into the Mad River.

Table 3-5. Production levels at hatcheries throughout the SONCC coho salmon ESU. Only those programs that influence natural populations are include

State	Hatchery	Coho Salmon Production	Chinook Salmon Production	Steelhead Trout Production
Oregon	Cole Rivers	200,000 (released into Rogue River)*	1.6 million (spring-run released into Rogue River)*	220,000 (summer-run released into Rogue River)*
				132,000 (winter-run released into Rogue River)*
				132,000 (winter-run released into Applegate River)*
	Elk River	Not Applicable**	110,000 (fall-run released into Chetco River)**	50,000 (winter-run released into Chetco River)**
			295,000 (fall-run released into Elk River)**	
California	Iron Gate	79,710***	6,280,978***	104,324***
	Trinity River	502,617***	4,434,995***	800,000***
	Mad River	Not Applicable	Not Applicable	203,943***

* Data from Cole Rivers Hatchery Operations Plan 2011

** Data from Elk River Hatchery Operations Plan 2011.

***Data from ICF/Jones & Stokes : 2010 CDFG Hatchery Operations Final Environmental Impact Report (EIR)/(EIS)

***Average Numbers and Pounds of Fish Produced and Stocked Annually from 2004 to 2008

Hatchery operations in Oregon and California were influential in the listing of SONCC coho salmon. Natural populations in the Klamath River, Trinity River, and Rogue River basins are heavily influenced by hatcheries (Weitkamp et al. 1995, Good et al. 2005). Hatchery practices have been shown to have altered the genetic composition (Reisenbichler and Rubin 1999, Ford 2002), phenotypic traits (Hard et al. 2000, Kostow 2004) and behavior (Berejikian et al. 1996, Jonsson 1997) of wild fish in these basins. Genetic changes in hatchery populations may be transferred to natural populations if hatchery fish spawn in the wild with non-hatchery fish, causing reduced fitness and productivity of the natural population. The potential magnitude of genetic effects depends on the species, number, size and location of the hatchery fish released, as

well as the potential overlap in spawn timing and habitat preferences between hatchery and native salmonid populations (ICF/Jones & Stokes 2010).

Hatcheries are artificial rearing environments that subject fish to substantially different conditions than those that wild fish have adapted to, and, as a result, apply different selection pressures on fish than would be encountered in natural environments (ICF/Jones & Stokes 2010). Interactions between hatchery and wild fish may result in two types of genetic hazards to wild salmon and steelhead populations: (1) loss of genetic diversity within and among populations, and (2) reduced fitness of a population affecting productivity and abundance. These different selective pressures may cause hatchery fish to change genetically with associated declines in fitness occurring as quickly as within one or two generations of captive rearing (Araki et al. 2008). Araki et al. (2008) summarized a number of studies that reported a loss of reproductive success ("fitness") of hatchery fish in nature. Additional problems from genetic interactions occur when hatchery fish stray into natural spawning grounds and spawn with wild fish. Straying of hatchery coho salmon is a frequent occurrence in all river systems where hatchery fish are propagated (Reisenbichler and Rubin 1999). The subsequent genetic interactions between hatchery and naturally produced stocks can decrease the amount of genetic and phenotypic diversity of a species by homogenizing once disparate traits of hatchery and natural fish. The result can be progeny with lower survival (McGinnity et al. 2003, Kostow 2004) and ultimately, a reduction in the reproductive success of the natural stock (Reisenbichler and McIntyre 1977, Chilcote 2003, Araki et al. 2007b), potentially compromising the viability of natural stocks via out breeding depression (Reisenbichler and Rubin 1999; HSRG 2004). It is believed that genetic risks associated with out-of-basin and out-of-ESU stock transfers have largely been eliminated since these activities have ceased. However, two significant genetic concerns from continuing practices remain: (1) the potential for domestication selection in hatchery populations such as the Trinity River, where there is little or no infusion of wild genes, and (2) out-of-basin straying by large numbers of hatchery coho salmon.

Additional concerns stem from the lack of quality control and management of released hatchery fish. Spawning by hatchery salmonids in rivers and streams is often not controlled (ISAB 2002) and hatchery fish can stray into rivers and streams, transferring genes from hatchery populations into naturally spawning populations (Pearse et al. 2007). Straying of hatchery fish in the Klamath Basin is common. Chesney and Knechtle (2010) found straying rates of hatchery fish into the Shasta River as high as 73 percent in 2008, and as low as 2 percent in 2007. Carcass surveys done in the 2009-2010 season found that out of 5 fish collected, one was marked with a left maxillary clip, indicating that it originated from Iron Gate Hatchery (Chesney and Knechtle 2010). Annual monitoring in the Scott River in the 2010-2011 season found all 81 coho observed to be marked. Three fish were observed during spawning ground surveys, and one was marked with a clip indicating it had originated from the Trinity River Hatchery (Chesney and Knechtle 2010). Non-native stock transfers are thought to have contributed to the low diversity and weak population genetic divergence observed in coho salmon stocks and likely was a factor when considering hatchery effects during listing (Brown and Moyle 1991, Bartley et al. 1992, Brown and Moyle 1994, Weitkamp et al. 1995, NMFS 2001).

Flagg et al. (2000) found that, depending on the carrying capacity of the system, increasing the number of hatchery fish released often decreases the number of naturally produced fish because the wild fish can get displaced from portions of their habitat. Kostow et al. (2003) and Kostow

and Zhou (2006) found that over the duration of the steelhead hatchery program on the Clackamas River, Oregon, the number of hatchery steelhead in the upper basin regularly caused the total number of steelhead to exceed carrying capacity, triggering density-dependent mechanisms that impacted the natural population. Similar effects can be found for the effects of hatcheries on coho salmon populations. Competition between hatchery and naturally-produced salmonids can also lead to reduced growth of naturally produced fish (McMichael et al. 1997). Competition between hatchery and natural salmonids in the ocean can also lead to density-dependent mechanisms that affect natural salmonid populations, especially during periods of poor ocean conditions (Beamish et al. 1997b, Levin et al. 2001, Sweeting et al. 2003). Competition for food, space, and other necessary resources can occur through two mechanisms:

- Individuals may preempt other fish from obtaining limited resources by depleting the resources first ('scramble' or 'exploitative' competition), or by actively preventing them from accessing resources ('contest' or 'interference' competition)" (ICF/Jones & Stokes 2010).

- Competition may result in reduced growth, displacement into suboptimal habitats, increased susceptibility to predation, and mortality (ICF/Jones & Stokes 2010).

Several hatchery species, including brown, brook, and lake trout, are exceptionally predatory or competitive with native salmonids. Brown trout are highly competitive and predatory with other fish species, particularly native trout, and "generally win, all things being equal (Sorenson et al. 1995). In the case of juvenile salmonids, competition is primarily for space rather than for food and other resources (Fresh 1997, Hearn 1987). Both juvenile and fresh water–resident adult salmonids are territorial and form distinct social hierarchies through aggressive interactions (i.e., interference competition) between individuals from the same species. Dominant individuals occupy preferred stream positions (i.e., locations where food can be acquired for the least amount of energy and where cover is nearby) and have the highest growth rates (Jenkins 1969, Griffith 1972). Introduced rainbow trout have been shown to disrupt these social hierarchies, resulting in reduced growth rates in Atlantic salmon (Blanchet et al. 2007). Comparable interactions may occur with native trout, such as various cutthroat races. Aggressive interactions between stocked and native salmonids may lead to a shift in the habitat niches used by native species and cause native fish to occupy suboptimal habitat or be displaced downstream, resulting in reduced growth or an increased susceptibility to predation. Once initial habitat shifts are made, differences in life stage timing, growth, and microhabitat preferences may reduce competition between species, given low fish densities (Blanchard 2002).

Another effect from the existence of hatcheries is the domestication of wild fish. Domestication occurs because, over time, hatchery populations become genetically adapted to their artificial environment, resulting in increased fitness under artificial conditions (domestication) but decreased fitness under natural conditions (Price 1984, Kohane and Parsons 1988, Hemmer 1990 *in* Hatchery Scientific Review Group (HSRG) 2004). Domestication results in morphological, physiological, and behavioral changes in hatchery fish that can affect both the fitness of the hatchery fish themselves and of the natural populations into which they are released. According to the HSRG (2004), some differences in hatchery fish that have been demonstrated include:

reduced expressions of morphological characters important during breeding, such as secondary sexual characters (Fleming and Gross 1989, 1994; Petersson and Järvi 1993); greater swimming activity, greater surface orientation, increased agonistic feeding behavior relative to natural fish (Ruzzante 1994; Campton 1995; Berejikian et al. 1996, Reinhardt 2001); increased vulnerability to predators under natural conditions (Berejikian 1995); behavioral dominance and aggression of juveniles that may result in competitive displacement of native fish from preferred habitats (Berejikian et al. 1996); earlier age at maturation, reduced egg size and numbers, and spawning hatchery adults that are generally less aggressive and more submissive to natural origin adults (Fleming and Petersson 2001); and hatchery females that show increased delays in the onset of breeding (Fleming and Gross 1994), fewer nests and greater retention of unspawned eggs (Fleming and Gross 1994; Fleming et al. 1996), and more likely for their eggs to be fertilized by several secondary males (most likely parr) than wild females (Thompson et al. 1999); and hatchery males that tend to be less aggressive and accomplish fewer spawnings than wild males (Fleming 1994).

In recent years, state guided efforts have begun to improve hatchery management practices, and work to decrease the potential negative effects of hatcheries and non-wild fish. The state of Oregon has developed several management policies and guidelines to decrease the negative impacts of hatchery fish on wild populations. In 1998, ODFW developed operational protocols with an emphasis on genetics and conservation management for coho stock in the Rogue River Cole Rivers Hatchery (ODFW 1998), and other management policies have been put into place to reduce the impacts of hatchery fish on SONCC coho salmon. More recently, Oregon adopted a Fish Hatchery Management Policy (ODFW 2003a) to guide many aspects of hatchery use, broodstock protocols, and the degree of interaction between hatchery and wild fish. ODFW's fish hatchery rearing programs are guided by the Native Fish Conservation Policy, the Fish Hatchery Management Policy and the Fish Health Management Policy (ODFW 2003a). Additionally, current fish management goals and hatchery program planning must respond to and adhere to the Oregon Plan for Salmon and Watersheds [formerly the OCSRI]. Some of the ways that the State of Oregon is decreasing negative effects of hatcheries and hatchery fish is by closely controlling broodstock origin. The Cole Rivers Hatchery coho salmon broodstock is of local origin with no out-of-basin stock introductions. This hatchery maintains broodstock and progeny are genetically and ecologically similar to wild populations, and this is maintained by incorporating a substantial number of wild coho salmon into the broodstock annually, with the goal of reducing genetic and ecological risks associated with hatchery spawning in the wild and interacting with wild juvenile coho salmon in the Rogue River basin (ODFW 2009).

In California, CDFG operates artificial propagation programs for coho salmon at two hatcheries (Iron Gate and Trinity River hatcheries) in the SONCC coho salmon ESU. These two hatcheries produce a large number of coho salmon (Table 3-5), with the percentage of hatchery fish exceeding desired ratios of hatchery to wild fish. A USFWS study conducted from 1995 to 2003 monitored relative smolt abundance in the Klamath River at Big Bar, above the confluence of the Trinity River. The study found that hatchery smolts comprised from zero to 66.7 percent of all captured coho salmon yearlings, reflecting the high Iron Gate Hatchery production. Between 1998 and 2000, Yurok Tribal Fisheries operated a downstream migrant trap in the lower Klamath River, below the confluence of the Klamath and Trinity rivers. The Yurok study estimated

marked Trinity River Hatchery smolts comprised 91 percent, 97 percent, and 65 percent of the catch in 1998, 1999, and 2000, respectively (Good et al. 2005). In 1998, a second trap was operated on the lower Trinity River. Only nine percent of the smolts captured at this trap were unclipped and considered naturally produced (ICF/Jones & Stokes 2010). Assuming that this proportion accurately reflected the relative contributions of naturally produced and hatchery Trinity River Hatchery fish to total catch at the Lower Klamath trap, the percent of hatchery fish exiting the Klamath River proper (above the Trinity confluence) was approximately 58 percent (ICF Jones & Stokes 2010). Hatchery fish make up an average of 16 percent of recovered carcasses in the Shasta River (Ackerman and Cramer 2006) and Trinity River Hatchery has a significant portion of fish straying and interacting with Trinity River wild populations (NMFS 2001). This high number of hatchery fish has been shown to have negative impacts on wild fish through genetic, behavioral, and physical changes. CDFG (2002b) found that 29 percent of coho salmon carcasses recovered (100 percent mark) at the Shasta River fish counting facility (SRFCF) had left maxillary clips in 2001, indicating IGH progeny. Although the actual percentages of hatchery fish in the river changes from year to year and depends largely on natural returns, these data indicate that substantial straying of IGH fish occurs in important tributaries of the Klamath River, and this straying has the potential to reduce the reproductive success of the natural population (Chilcote 2003, Mclean et al. 2003, Araki et al. 2007a) and negatively affect the diversity of the interior Klamath populations via outbreeding depression (Reisenbichler and Rubin 1999, HSRG 2004).

3.1.2 Impaired Water Quality

One of the most important ecological requirements of coho salmon is cold, clean, well-oxygenated water. Current water quality parameters reduce populations throughout much of the SONCC coho salmon ESU. Impaired water quality parameters include increased water temperature, changes in pH above or below optimum levels, reduced dissolved oxygen, increased nutrient loading, and increased extent or duration of turbidity, or both. Some of the activities that impair water quality include water diversions, in-channel construction, riparian vegetation reduction, agriculture, alteration of the streambed and banks, components of timber management, and the introduction of point- and non-point source pollution from urbanization and industrialization. NMFS concluded that impaired water quality is either a high or very high stress (limiting factor) in 24 out of 41 populations in the SONCC coho salmon ESU, and is largely characterized by increased in water temperature, decreased dissolved oxygen, and increased turbidity (Table 3-4; Volume II).

Increased water temperature is one of the most widespread (and greatest) stresses (limiting factors) in the SONCC coho salmon ESU. Water temperature influences coho salmon growth and feeding rates (partly through increased metabolism), development of embryos and alevins (McCullough 1999),as well as timing of life history events such as freshwater rearing, seaward migration (Holtby et al. 1989), upstream migration and spawning (Spence et al. 1996). Increased water temperature can be detrimental to the survival of most life stages of coho salmon, but in the SONCC coho salmon ESU summer-rearing juveniles are the most likely to be affected by elevated water temperatures. Elevated water temperature can result in increased levels of stress hormones in coho salmon, often resulting in mortality (Ligon et al. 1999). Increased water temperature, even at sub-lethal levels can inhibit migration, reduce growth, stress fish, reduce reproductive success, inhibit smoltification, contribute to outbreaks of disease, and alter

competitive dominance (Elliott 1981). Increases in water temperature may result from changes in the quantity and quality of riparian vegetation, the presence of dams, water diversions, other anthropogenic activities, and have also been correlated to large-scale (or localized) climate change and precipitation. Additionally, threats including timber harvest, urbanization, roads, and other land use activities are expected to continue to affect water temperatures within the SONCC coho ESU.

In addition to appropriate water temperatures, salmonids need adequate concentrations of dissolved oxygen for the survival of all life stages (Spence et al. 1996). Reduced levels of dissolved oxygen can impair the growth (Herrmann et al. 1962) and developmental (Silver et al. 1963) processes of various life stages of salmon, including eggs and fry. Low dissolved oxygen can also decrease the swimming (Davis et al. 1963), feeding and reproductive ability of juveniles and adults (Bjornn and Reiser 1991). Such impacts can affect fitness and survival by altering embryo incubation periods, decreasing the size of fry, increasing the likelihood of predation, and decreasing feeding activity (Carter 2005). Under extreme conditions, low dissolved oxygen concentrations can be lethal to salmonids (Bjornn and Reiser 1991).

Nutrient contributions from sources such as fertilizer run-off, livestock, and septic systems may foster algae blooms that can contribute to elevated pH levels, increase ammonia toxicity, and depressed dissolved oxygen levels. Algae and other aquatic plants create diel (24 hour) cycles in which photosynthesis causes high pH during daylight hours and respiration causes low dissolved oxygen at night (Nimick et al 2011), which may be stressful or lethal to salmonids. Additional water quality impairments may be caused when large algae blooms begin to decay and increase the biological oxygen demand (Lathrop et al. 1998, Landsberg 2002). These water quality problems may exacerbated by reduced flows.

Both acidic (pH <6.5) or alkaline conditions (pH >8.5) can cause salmonid stress (Spence et al. 1996). Adverse effects from low pH can occur at levels that are not lethal to adult fish, but which can impair reproduction and other processes. Reproductive impairments include altered spawning behavior, reduced egg viability, decreased emergence success and reduced survival of the early life stages which are known to be the most vulnerable to low pH (Jordahl and Benson 1987). Conversely, chronic high pH levels in freshwater streams can also decrease activity levels of juvenile salmonids, induce stress responses, cause decreased or cessation of feeding, and may lead to a loss of equilibrium (Murray and Ziebell 1984). Prolonged exposure to pH levels of 8.5 or greater may exhaust the ion exchange capacity at gill membranes and lead to increased alkalinity in the bloodstream of salmonids (Wilkie and Wood 1995). If water temperatures are high (e.g. 25°C), then high pH may also cause conversion of ammonium ions to highly toxic dissolved ammonia (Goldman and Horne 1983).

One of the most wide scale changes in water quality in the SONCC coho salmon ESU is increased turbidity and suspended sediment. Increases in turbidity, changes in the quantity and quality of suspended sediment, and associated decreases in water quality can be caused by a variety of activities including logging, grazing, agriculture, mining, road building, urbanization, and construction (Bash et al. 2001). These activities, when performed in excess or without proper management, have been shown to have the ability to contribute to periodic pulses or chronic levels of suspended sediment in streams (Bash et al. 2001) and likely have a wide range of effects on all life stages of salmonids. Effects from increasing sediment loads and turbidity

range from lethal to sublethal (Newcombe and McDonald 1991), and arise from physiological stress (e.g., gill trauma, changes in blood sugar levels and osmoregulatory function, susceptibility to disease), loss of spawning and rearing habitat, and alteration of behaviors (e.g., avoidance, territoriality, and foraging) that affect salmonid growth and survival.

The most common behavioral alteration associated with increased turbidity is reduced juvenile salmonid feeding behavior. Data indicate that there is an inverse relationship between turbidity and feeding efficiency or prey ingestion (Berg 1982, Berg and Northcote 1985, Sweka and Hartman 2001)-and as turbidity increases, feeding efficiency decreases. Salmonids are visual predators that feed largely on drifting invertebrates, and changes in efficiency can be correlated to a decrease in their reactive distance to prey as turbidity increases. Published data suggest that feeding efficiency of juvenile coho salmon may drop by 45 percent at a turbidity level of 100 Nephelometric Turbidity Units (NTUs) (Berg 1982) and that turbidity as low as 70 NTU reduced salmonid foraging effectiveness and delayed their response to food (Bisson and Bilby 1982).

Water Quality Programs

Federal and state programs exist to maintain and improve water quality conditions throughout the SONCC coho salmon ESU. Both California and Oregon have statewide water quality programs aimed at improving current water quality conditions, and the U.S. Environmental Protection Agency (USEPA) works closely with both states to identify and improve conditions in impaired watersheds.

In 1969, the California Legislature enacted the Porter-Cologne Water Quality Control Act (the Act) to preserve, enhance and restore the quality of the State's water resources. The Porter-Cologne Act is the principal law governing water quality in California. Unlike the Clean Water Act, Porter-Cologne applies to both surface water and ground water. Beyond establishment of the state framework, this act has been revised to comply with the federal Clean Water Act.

The Act established the State Water Resources Control Board and nine Regional Water Quality Control Boards (RWQCBs) as the principal state agencies with the responsibility for controlling water quality in California. Under the Act, water quality policy is established, water quality standards are enforced for both surface and ground water, and the discharges of pollutants from point and non-point sources are regulated. The Act authorizes the State Control Board to establish Water quality principles and guidelines for long range resource planning including ground water and surface water management programs and control and use of recycled water. The California Coastal Act of 1976 extended the California Coastal Commission’s authority indefinitely. The California Coastal Commission was established by a voter initiative in 1972, and provides oversight for projects that impact water resources along the California coast. The California Coastal Commission has joint responsibility with the State Board and Regional Boards for implementation of the state’s Nonpoint Source Program (see section 319 of the Clean Water Act, section 309 of the Coastal Zone Management Act of 1972, and section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990).

The Oregon Department of Environmental Quality (ODEQ) is the state agency responsible for protecting Oregon’s surface waters and groundwater. The ODEQ’s Water Quality Program develops water quality standards for Oregon’s waters, monitors water quality in designated river

basins, regulates point source discharges, regulates injection systems by issuing permits to protect groundwater, and controls nonpoint sources of pollution through statewide management plans (available at: http://www.deq.state.or.us/wq/nonpoint/plan.htm). Oregon has established both numeric and narrative water quality criteria, but does not have streamflow criteria to protect streamflow at this time. Antidegredation rules exist in areas around the state and help to maintain water beneficial uses of water. ODEQ is the state agency tasked with developing and implementing TMDLs.

Using the Oregon Water Quality Index to monitor trends in water quality, ODEQ regularly collects water samples at over 150 sites on more than 50 rivers and streams across the state. ODEQ visits most sites six times annually and test a number of water quality variables at each visit. The state has monitored some sites routinely since the late 1940s (available at http://www.deq.state.or.us/lab/wqm/docs/09-LAB-004.pdf). The data are used to determine whether there is too much pollution in a water body, and set limits on how much pollution a water body can receive. The ODEQ also maintains a volunteer water quality monitoring program around the state, providing equipment and assistance to volunteers and groups wanting to assist in water quality data collection (available at: http://www.deq.state.or.us/lab/wqm/docs/08-LAB-015.pdf). Oregon's Water Quality Nonpoint Source Control Program Plan (ODEQ 2000) identified the pollution management programs, strategies, and resources that were currently in place or that were needed to minimize nonpoint source pollution effects. The plan integrates a variety of other state and federal initiatives, and the state is currently completed the process of re-evaluating the program.

The Clean Water Act (CWA) is the most well known federal policy aimed at improving and protecting water resources around the United States. The CWA was adopted "to restore and maintain the chemical, physical and biological integrity of the Nation's waters" (33 U.S.C. § 1251 et seq.). Under section 303(d) of the CWA, States are required to identify those waters that are not meeting water quality standards or supporting beneficial uses, including fisheries resources. Section 303 of the federal Clean Water Act (33 USC §1313) defines water quality standards as consisting of both the uses of the surface (navigable) waters involved and the water quality criteria which are applied to protect those uses. These waters are placed on the State's Section 303(d) list and submitted to USEPA for review and approval. Under the Clean Water Act the Oregon Department of Environmental Quality (ODEQ) and the WQCBs must develop total maximum daily loads (TMDLs) to limit the pollutants that are impairing those water bodies.

Since the initial listing of SONCC coho salmon many TMDLs have been completed (Table 3-6), and California and Oregon are working to manage excessive pollutants and other water quality impediments. TMDLs in California are developed either by Regional Water Quality Control Boards (RWQCBs) or by the USEPA. TMDLs developed by RWQCBs are designed as Basin Plan amendments and include implementation provisions. TMDLs developed by USEPA typically contain the total load and load allocations required by Section 303(d), but do not contain comprehensive implementation provisions. This stems from the fact that USEPA authorities related to implementation of nonpoint source pollution control measures are generally limited to education and outreach as provided by CWA Section 319. The beneficial use of salmonid fishes is most often affected by non-point source sediment and temperature impairments, so development of non-point source TMDLs is important. The ability of these

TMDLs to protect coho salmon in Oregon and California is expected to be significant in the long term, however, it is difficult to implement them. Ultimately their efficacy in protecting coho salmon habitat will depend on how well the protective measures are implemented, monitored, and enforced.

Table 3-6. List of total maximum daily loads (TMDLs) in the range of the SONCC coho salmon ESU and their status. Data from the North Coast Regional Water Control Board website.

Watershed	Pollutant(s)	TMDLs Status	Watershed	Pollutant(s)	TMDL Status
Mattole River	Sediment and Temperature	Completed - 2004	Redwood Creek	Sediment and Temperature	Completed - 1998
Lower Eel River	Sediment and Temperature	Completed - 2007	Klamath River	Nutrients, Temperature, Low Dissolved Oxygen	Completed - 2010
Van Duzen River	Sediment	Completed - 1999	Salmon River	Temperature	Completed - 2005
Middle Fork Eel River	Sediment and Temperature	Completed - 2003	Scott River	Sediment and Temperature	Completed - 2005
Middle Mainstem Eel River	Sediment and Temperature	Completed - 2004	Shasta River	Organic enrichment, Low DO, Temperature	Completed - 2007
North Fork Eel River	Sediment and Temperature	Completed - 2002	Trinity River	Sediment	Completed - 2001
South Fork Eel River	Sediment and Temperature	Completed - 1999	South Fork Trinity River	Sediment and Temperature	Completed - 1998
Upper Mainstem Eel River	Sediment and Temperature	Completed - 2004	Upper Rogue River	Bacteria, DO, pH, Sediment, Temperature	Completed - 2008
Elk River	Sediment	In Progress	Middle Rogue River	Bacteria, Sediment, Temperature	Completed - 2008
Freshwater Creek	Sediment	In Progress	Lower Rogue River	Bacteria, Temperature	Completed - 2008
Humboldt Bay	PCBs	In Progress	Illinois River	Temperature	Completed - 2008
Jacoby Creek	Sediment	In Progress	Chetco River	Bacteria, DO, pH, Temperature	Initiated
Mad River	Sediment, Turbidity, Temperature	Completed - 2007	Applegate River	Temperature, DO	Completed - 2004

In addition to federal water quality policy, tribes along the Klamath River have developed water quality standards for their lands, and developed their own water quality control plans. Under CWA section 518(e) (33 U.S.C. § 1377(e)), tribes may apply to the USEPA to be treated as a State for purposes of various listed sections of the CWA, and USEPA-approved tribal water quality standards are similar to USEPA TMDLs, and help protect fish and water quality both upstream and downstream of tribal lands. The Hoopa Valley, Yurok, and Karuk tribes have all developed water quality control plans (Hoopa Valley Tribe Environmental Protection Agency

2008, Yurok Tribal Environmental Program (YTEP) 2004, Karuk Tribe of California 2002) and the Quartz Valley and Resighini Rancherias have developed water quality programs (Quartz Valley Indian Reservation 2009, Resighini Rancheria Environmental Department 2006).

3.1.3 Degraded Riparian Forest Conditions

Riparian habitat provides significant benefits to freshwater aquatic systems and the biota that live within and around it (Welsch 1991). Riparian area structure and composition throughout the ESU has changed due to irrigation diversions, timber harvest, farming, grazing, wildfire, and urbanization, which all contribute to a high or very high ranking of *degraded riparian forest conditions* in 34 populations in the ESU (Table 3-4; Volume II). Aquatic functions and processes dependent upon properly functioning riparian areas have been reduced accordingly. Major floods occurring in the years 1955, 1964, 1974, 1986, 1997, and 2006 caused significant damage to riparian areas in almost every population area in the ESU. Consequently, species diversity has been reduced and channel functions—such as sediment transport and storage—have been severely altered or is lacking in many areas. As mentioned above, there are myriad anthropogenic activities that can contribute to the degraded riparian conditions, many of which are occurring in populations within the SONCC coho salmon ESU. Livestock grazing, urbanization, and certain timber harvest practices, can, and do, affect the riparian environment by reducing the amount and composition of riparian vegetation, or may eliminate sections of riparian areas. Eliminating or decreasing riparian areas may result in stream channelizing and straightening, channel widening, channel aggradation, and lowering of the water table (Belsky et al. 1999). Effects on fish habitat from these activities include: reduction of streamside shade and cover, decreases in large wood recruitment, decreases in allochthonous materials (material formed or introduced from somewhere other than the place it is presently found), increases in stream temperature, changes in water quality and stream morphology, and the addition of sediment through bank degradation and off-site soil erosion (Cohen 1997, Forest Ecosystem Management Team (FEMAT) 1993, Spence et al. 1996). Riparian vegetation helps to maintain instream water quality by filtering nutrient runoff, and this process is altered or completely absent when riparian vegetation is cleared for agricultural activities or urban development (Welsch 1991). In addition, coarse woody debris associated with riparian corridors provides structure for shade, cover, bank stabilization, breeding sites for some amphibians and invertebrates, and these functions are lost when trees are removed from an area (Moseley et al. 1998).

3.1.4 Increased Disease/Predation/Competition

Disease and predation are locally significant throughout the ESU, and are likely limiting the recovery of some SONCC coho salmon populations. Currently, disease and predation are listed as a high or very high stress to 4 populations in the ESU (Table 3-4). Impacts from diseases are likely being exacerbated by human induced environmental impacts and activities, such as alteration of hydrologic functions (damming and diverting), impaired water quality conditions, hatchery practices, habitat alterations, and changing climatic conditions. Coho salmon are exposed to numerous bacterial, protozoan, and parasitic pathogens throughout their lives, and have evolved with exposure to these and other organisms (Stocking and Bartholomew, 2004). Susceptibility to disease changes according to fitness level, environmental condition, and overall health. When water quality deteriorates, diminished flows cause crowding and stress, or when

parasite spore loads are extremely high, then lethal disease outbreaks can occur (Foott 1995, Spence et al., 1996, Guillen, 2003,CDFG 2003, YTEP 2004, Nichols and Foott 2005). Disease issues arise when the interaction between host and pathogen is altered and when natural resistance levels become impaired by stressful environmental conditions or decreased fitness levels. Within the last few decades, the prevalence of diseases in wild stocks has become of increasing concern, and has begun to be a factor in the continuing survival and viability of wild stocks of coho salmon (CDFG 2002a).

Diseases can affect coho salmon in almost any life stage where exposure occurs. Some diseases infect returning adults as they enter bays and estuaries, while other diseases attack or kill juveniles rearing upstream. Many pathogens may remain dormant in juveniles, or when conditions are not stressful, and then appear symptomatically when fish return to freshwater and conditions become stressful. Different life stages have different susceptibilities, making it difficult to discern time of infection or disease infection rates and causes. Known diseases and disease agents that can cause significant losses to adults include: bacterial kidney disease (BKD) (*Renibacterium salmoninarum*), furunculosis (*Aeromonas salmonicida*), columnaris (*Flexibacter columnaris*), *pseudomonas/aeromonas*, and *ichthyopthirius* or "Ich" (*Ichthyopthirius multifilis*). Juvenile salmonids are primarily affected by furunculosis, columnaris (*Flavobacterium columnare*), coldwater disease (*Flexibacter psychrophilis*), *Nanophyetus salmonicola*, Aeromonid bacteria, pseudomonas/aeromonas, ichthyopthirius, the kidney myxosporean *Parvicapsula minibicornis*, and ceratomyxosis (*Ceratomyxa shasta*) (CDFG 2002a, Federal Energy Regulatory Commission (FERC) 2007).

These diseases proliferate when fish are stressed by high water temperatures, crowding, environmental contaminants, or decreased oxygen (Warren 1991). In addition, it has been shown that water quantity and quality during the late summer months is critical in controlling or triggering disease epidemics, and that decreases in these variables may trigger the onset of epidemics in fish that are carrying the infectious agents (Holt et al. 1975, Wood 1979, Matthews et al. 1986, Maule et al. 1988). As epidemic disease breakouts occur more frequently, problems remain in identifying the proximate and ultimate causes of death, and the subsequent effect that these are having on population survival numbers. The lack of data continues to hamper the efforts of managers to understand the full effect that disease is having on coho salmon populations.

Although not emphasized in the original listing document, ceratomyxosis, which is caused by C. shasta, is one of the most significant diseases for affecting juvenile coho salmon due to its prevalence and impacts in the Klamath Basin (Nichols et al. 2003). Bartholomew et al. (2006) believes that the recent increases in air temperature may be compounding the disease potential in the Klamath basin. High water temperature, low dissolved oxygen, high pH (alkalinity) and possibly unionized ammonia in the mainstem Klamath River create stressful conditions for all ages and types of salmonids which in turn can increase disease transmission and potential effects to individuals. Severe infection of juvenile coho salmon by C. shasta may be contributing to declining adult coho salmon returns in the Klamath basin (Foott et al. 2010). Mortality rates from temporary and longer term exposures at various locations in the Klamath River vary between location, months and years, but are consistently high (10 to 90 percent) (Bartholomew 2008). In addition, parasitic infections by *Parvicapsula minibicornis* have been detected in 65 percent of young of the year of a year class and 71 percent of yearling coho salmon in the

mainstem Klamath River (Nichols et al. 2008). Additionally, the Klamath River below Iron Gate Dam supports large populations of the intermediate host (a polychaete worm) of *Ceratomyxa shasta* due to an abundant food supply (particulate organic matter) and ample amounts of its two favored substrates (fine particulate organic matter that settles on the bottom of the river bed and mats of the attached algal species *Cladophora* which are stimulated by high nutrient levels). Ceratomyxosis has been responsible for most of the mortality of Klamath River juvenile salmonids in recent years. Mortality rates from temporary and long-term exposures at various locations in the Klamath River vary between location, months and years, but are consistently high (between 10 and 90 percent; Bartholomew 2008). Adults in the Klamath basin are also largely impacted by other diseases, primarily from the common pathogens *Ichthyopthirius multifilis* (Ich) and *Flavobacterium columnare* (columnaris) (National Research Council (NRC) 2004). These pathogens were partially responsible for the 2002 adult fish kill on the Klamath River (USFWS 2003). During this event over 300 coho salmon and 34,000 Chinook salmon were killed by a disease epizootic from Ich and columnaris, which was exacerbated by stressful conditions in the Klamath River (CDFG 2004). Adult mortality from ich and columnaris are not as common as juvenile mortality from *C. Shasta* or *Parvicapsula minibicornis* (Bartholomew et al. 2003).

At the time of listing, predation had been listed as a factor contributing to the decline and listing of coho salmon in the SONCC ESU, but more recent data suggests that it is a bigger problem than originally thought. Notable predators include non-native Sacramento Pikeminnow and hatchery fish, as well as predation by other non-native species in some areas. These impacts are exacerbated by habitat modification, impaired water quality, hatchery practices, and other anthropogenic activities (Marine and Cech 2004).

In some watersheds, the rapid expansion of invasive predator populations was facilitated by alterations in habitat conditions (particularly increased water temperatures) that favor these species (Brown et al. 1994). Non-native fishes such as Sacramento pikeminnow (*Ptychocheilus grandis*), smallmouth bass (*Micropterus dolomieu*), brown trout (*Salmo trutta morpha fario*) and channel catfish (*Ictalurus punctatus*) can consume significant numbers of juvenile salmon (NMFS 1998). Sacramento pikeminnow have been observed throughout the Eel River basin and are thought to be a serious predator that is likely limiting juvenile coho salmon survival (CDFG 1994, 2004; NMFS 1996). In the Trinity River, brown trout are abundant enough to make up a substantial proportion of observations by biologists collecting juvenile salmonid habitat utilization data (Martin 2009) and it is likely that they consume naturally produced fry and juvenile coho salmon. Without adequate avoidance habitat (deep pools and undercut banks), and adequate flows for migration and rearing, predation can have a significant negative effect on juvenile salmonid growth (Quinn and Peterson 1996, Schlosser 1987, Bugert and Bjornn 1991, Bjornn and Reiser 1991, Brown 1999).

In addition to non-native species, hatchery fish can exert predation pressure on juvenile coho salmon. Native fishes in coastal streams and rivers have generally co - evolved with native salmon and steelhead, which are also used for hatchery stocks. Under natural conditions native fishes may subsist with minimal, if any, negative interactions with salmon and steelhead in rivers and streams. The addition of large numbers of hatchery fish at one time and location, such as that which occurs under salmon and steelhead stocking programs, may potentially result in locally elevated rates of predation and competition (ICF/Jones & Stokes 2010). The potential for

predation and competition between hatchery - reared and naturally produced salmonids depends on the degree of spatial and temporal overlap, differences in size and feeding habitats, migration rate and duration of freshwater residence, and the distribution, habitat use, and densities of hatchery and natural juveniles (Mobrand et al. 2005). Recently, concern has been expressed about the potential for hatchery - reared salmon and steelhead to prey on or compete with wild juvenile Pacific salmonids (Oncorhynchus spp.) and the impact this may have on threatened or endangered salmonid populations (Williams 2006). Released at larger sizes and in great quantity, hatchery-reared salmonids prey on naturally-produced juvenile coho salmon (Kostow 2009). For example, predation by hatchery fish may result in the loss of tens of thousands of naturally produced coho salmon fry annually in some areas of the Trinity River (Naman 2008). Nickelson (2003) demonstrated that the productivity of wild coho salmon in 14 Oregon coastal basins was negatively correlated to the average number of hatchery smolts released into these basins, suggesting strong ecological interactions between hatchery and wild fish. Nickelson (2003) also reviewed evidence for the role of behavior and concluded that large numbers of hatchery fish likely increase mortality of wild fish by attracting predators and/or increasing their exposure to predators.

Predation by marine mammals (principally seals and sea lions) is of concern in areas experiencing dwindling run sizes of salmon (69 FR 33102, June 14, 2004). However, salmonids appear to be a minor component of the diet of marine mammals and therefore this type of predation is likely not contributing significantly to further decreases in run sizes (Scheffer and Sperry 1931, Jameson and Kenyon 1977, Graybill 1981, Brown and Mate 1983, Roffe and Mate 1984, Hanson 1993, Goley and Gemmer 2000, Williamson and Hillemeier 2001). Among other mammalian predators that can impact salmonid populations in freshwater areas, mink (*Mustela vison*) and otter (*Lutra canadensis*) can take significant numbers of overwintering coho salmon juveniles and migrating smolts, although this is dependent upon conditions favorable to predators and the availability of other prey (Sandercock 1991).

3.1.5 Altered Sediment Supply

The alteration in the quantity and composition of the sediment supply into streams and rivers is a stress created through a variety of human induced threats. These threats include roads, agricultural practices, mining and gravel extraction, timber harvest, and urbanization. Impacts caused by these activities include changes to the size and composition of sediment entering the stream(Kaufmann et al. 2009, Opperman et al. 2005), changes to the quantity of sediment (Reid et al. 2010), and alterations in the timing of sediment entering stream channels (Cordone and Kelley 1961). Throughout the ESU, changes in the quantity of fine sediment have been one of the most documented effects of changes in land use. Altered sediment supply is a high or very high stress in 29 populations in the SONCC coho salmon ESU (Table 3-4). Increased sedimentation has been shown to have direct negative effects on coho salmon through interfering with their physiological and biological processes, have indirect effects through degradation of their habitat (Cordone and Kelley 1961, Koski 1966, Kondolf 2000), as well as decreasing the production of macroinvertebrates that are an important food source for fry, juveniles, and smolts (Suttle et al. 2004, Cover et al. 2008). Elevated rates of suspended sediment from increases in fine sediment may result in gill abrasion, suffocation of eggs (Greig et al. 2005), impaired water quality, and reduced feeding success (Newcombe and McDonald 1991). Increased fine sediment levels can reduce juvenile salmonid growth rates by decreasing macroinvertebrate prey and

increasing metabolic demands due to reduced availability of sheltered microhabitats (Suttle et al. 2004). Conversely, a reduced sediment supply can limit the availability of spawning substrate, alter availability of velocity refugia and macroinvertebrate habitat, and can cause large scale changes in the morphology of downstream reaches (Cordone and Kelley 1961).

High concentrations of suspended solids degrade water quality by reducing water clarity and decreasing light available to support photosynthesis. Reduction in photosynthesis and the subsequent reduction in plant matter may then lead to decreased food and habitat (ICF/Jones & Stokes 2010). Furthermore, as photosynthesis slows, less oxygen is released into the water during daytime. These impacts can culminate in the death and decay of aquatic plants, resulting in further DO depletion and exacerbating already reduced DO levels (ICF/Jones & Stokes 2010).

Many of the historic and ongoing anthropogenic activities in the ESU have caused changes to the amount and timing of sediment delivery to streams. This is most often seen as an increased amount of fine sediment and associated aggradation within the stream channel. Accelerated rates of erosion and increased sediment delivery to streams after timber harvest and road construction are common occurrences in the mountainous, forested watersheds that are common in the ESU (Sidle et al. 1985, Montgomery et al. 2000), and have been shown to deliver higher than average quantities of fine sediment. Such increases in the timing and quantity of the supply of sediment to streams can cause dramatic changes to channels, including increased fine sediment, aggradation (sediment deposition), widening, changes in the timing and intensity of flows, and pool filling, especially in lower gradient reaches (Kelsey 1980, Lisle 1982, Roberts and Church 1986, Knighton 1991). It can take decades for channels to recover following large aggradation events (Madej et al. 2009). As stream velocities decrease, these large quantities of suspended solids may be deposited within the streambed and alter aquatic habitat (ICF/Jones & Stokes 2010). Settling fine sediments also fill spaces between rocks, thereby reducing the habitat value for benthic organisms, and decreasing prey availability (ICF/Jones & Stokes 2010). In this way, reduced water clarity from high suspended sediment loads can affect predator-prey relationships, clog or abrade sensitive fish gills, and abrade soft tissues (ICF/Jones & Stokes 2010). There is also the potential for alteration of floodplains and other flood prone areas, where large amount of sediment can bury riparian vegetation, increase the height of stream banks, and disconnect floodplain and floodprone areas. These alterations in geomorphology (i.e. excess sediment buildup, changes in proportion of fines) can result in increases in the frequency and magnitude of localized flood events, causing cumulative damage. In small instances, increased sediment loads can affect the near stream environment in other ways by positively altering the diversity and density of riparian vegetation and indirectly altering water temperature and other aquatic habitat parameters (Birtwell 1999).

Changes have also been documented in the size and quantity of coarse bed materials being delivered to streams throughout the ESU. Many of the activities discussed above have the ability to alter the quantity and composition of coarse sediment in streams. Coarse sediment serves an important function to river systems by being an essential feature of spawning and rearing habitat for coho salmon (Lorenz and Eiler 1989). Alluvial rivers, such as found in the SONCC ESU, can function properly only if continuously supplied with this coarse bed material. This supply is cut off when dams are built, mining removes excessive amounts of gravel, or the hydrology of the system is altered to decrease frequency and magnitude of flows that mobilize these sediments. Coarse sediment is an essential component of geo-fluvial mechanisms such as

scouring and gravel bar development, and it has been shown that dams and other man-made barriers trap this coarse sediment that historically was delivered downstream (Kondolf 1997), permanently altering channel bed morphology and impacting instream habitat. Within the SONCC coho salmon ESU, major dams on the Eel, Klamath, Applegate, Rogue, Shasta and Trinity rivers are of particular concern because they impede coarse sediment transport downstream into areas inhabited by coho salmon. When occasional high flow releases from dams scour the channel bed and mobilize bed material downstream without replacement from upstream sources, the net effect can be channel downcutting. These occasional high flow releases tend to transport only the finer fraction of the stream channel, leaving the coarser particles behind, and can eventually create an immobile channel (Kondolf 1997). Changes such as these create a significant stress on coho salmon, which rely on the natural dynamic structure of a river for instream cover, deep pools, appropriately sized spawning substrate and off-channel habitats, all of which cease to be created when the channel bed becomes immobile. These changes can last long after the dam or other structures are removed, and work to restore these areas may take years and even decades.

3.1.6 Lack of Floodplain and Channel Structure

Low-gradient rivers and streams with active floodplains are ecologically important to coho salmon, but are highly susceptible to anthropogenic land use changes and alterations in channel morphology. Changes in floodplain and channel structure may result from a number of activities, such as agricultural practices, timber harvest, mining and gravel extraction, building of dams, the building of roads, and urbanization and development of riparian areas. Legacy impacts continue through projects that were originally built to protect urban, residential, transportation and agricultural land uses, but continue to alter channel migration, block off channel habitat, and impact side channel habitats. Unconstrained reaches of lowland rivers provide diverse, slow water habitats for salmonids, including side-channels, lakes, backwaters, alcoves, sloughs, and beaver ponds (Independent Multidisciplinary Science Team (IMST) 2002) that are essential for juvenile survival and rearing success. In unconstrained stream reaches, valley walls do not impede lateral channel migration. The resulting complex structure provides important habitats for salmonids (IMST 2002) and allows for rearing in floodplain areas and off channel habitats that may not be available in other areas of the watershed. Reduced hydrological connectivity may render these areas disproportionately susceptible to inter-annual variations in winter and summer stream flows (Sommer et al. 2005). When floodplains and off-channel habitats become disconnected, juvenile fish can be displaced downstream during high flow events, can encounter mortality from physical damage caused during high flows, and experience a decrease in the ability to survive through the winter from decreases in prey resources and slow water rearing and holding areas.

Many areas within the SONCC coho salmon ESU have been straightened, diked and leveed to allow for urbanization, road building, and increases in the quantity of agricultural areas. Stream channels that have been straightened, diked, and leveed cause harmful effects to salmonids through decreases of natural pool, winter rearing, and spawning habitats, while channel simplification also indirectly causes changes in the timing of peak flows, increases in the quantity of scour events, and changes in the movement of sediment through the system (IMST 2002). Lack of floodplain and channel structure was ranked as a high or very high stress (limiting factor) for 37 populations in the SONCC ESU (Table 3-4). This is a huge stress for the

ESU as a whole, because unconstrained, low elevation reaches often have the greatest abundance of salmonids, the greatest diversity of habitats, and the greatest potential to be impacted by anthropogenic activities (Reeves et al. 1998).

One the most important contributors to lack of floodplain and channel structure in the SONCC coho salmon ESU is a paucity of instream large wood. Large wood plays a critical role in creating and maintaining the habitat complexity necessary for high quality coho salmon rearing habitat. Coho salmon juveniles favor pools that contain shelter provided by large wood (Reeves et al. 1989). Research from across the Pacific Northwest has shown that streams with more large wood have more pools because large wood provides scour-forcing obstructions that create pools (Montgomery et al. 2003, Buffington et al. 2002). Larger pieces of wood are more stable than smaller pieces of wood, and ratio of log length to channel width can be used as a gauge of stability (Montgomery et al. 2003). Past and current timber harvests have degraded riparian forests across the SONCC coho salmon ESU, decreasing the number of large conifers in riparian zones and reducing the potential for recruitment of long-lasting large wood. Hardwood trees like alder and willow are now the most abundant species in many riparian zones. These hardwood species do not provide long lasting large wood for channel forming processes (Cederholm et al. 1997) and their maximum potential size, and therefore stability, is much smaller than conifers. Further contributing to the lack of instream large wood were misguided attempts to improve fish habitat by removing wood from streams during second half of the twentieth century. As a result, the amount of large wood in streams is currently far lower than historical levels, resulting in serious degradation of the capacity of stream habitats to support coho salmon rearing due to lack of pools and reduced habitat complexity.

The historic decline in beaver (*Castor canadensis*) populations is another major contributor to lack of floodplain and channel structure. Beaver ponds provide excellent winter and summer rearing habitat for coho salmon (Reeves et al. 1989, Pollock et al. 2004). Beavers were highly valued for their fur pelts and from the 1780s to 1840s, trappers swept through the Pacific Northwest, reducing the formerly robust beaver population to remnant levels (ODFW 2005b). The resulting effect of decreased beaver abundance on coho salmon populations was likely very significant. For example, a study of the Stillaguamish River Basin in Washington compared current conditions with estimated historical conditions and concluded that the loss of beaver ponds accounted for most of the estimated 86 percent reduction in smolt production potential (SPP) of winter habitat and most of the 61 percent reduction of SPP for summer habitat (Pollock et al. 2004). Although still much reduced from pre-trapping levels, beaver populations have rebounded somewhat since the end of the era of intensive trapping. Recent studies in the Lower Klamath, Middle Klamath and Shasta subbasins confirm that beaver ponds provide high quality summer and winter rearing habitat for coho salmon (Chesney et al. 2009, Silloway 2010). Information regarding the distribution and abundance of beavers within the SONCC coho salmon ESU is relatively limited (Riverbend Sciences 2011). In Oregon, ODFW fish habitat surveys detected beaver dams in the Rogue River basin but not in the Brush Creek, Mussel Creek, Hunter Creek, Pistol River, or Chetco River basins (although only a small portion of the Chetco basin was surveyed); there are no survey data available for Elk River or Winchuck River. In California, beavers are present in the Smith River, Klamath River, Redwood Creek, and Mad River basins but it is unknown whether they are present in the other coastal streams between the Smith River and Mad River. Beavers are absent in Humboldt Bay, Bear River, Mattole River, and most of the Eel River basin with the exception of Outlet Creek and mainstem Eel River in

the vicinity of Cape Horn Dam (Riverbend Sciences 2011). Despite their considerable contribution to creating and maintaining rearing habitat for endangered coho salmon, beavers are classified as a predatory species in Oregon and current regulations allow private landowners to destroy beavers and their habitat without notification to state agencies. In California, recreational trapping is allowed and depredation permits are issued by CDFG to private landowners to destroy problematic beavers.

3.1.7 Altered Hydrologic Function

Throughout the ESU, the hydrologic function of many rivers and streams has been severely altered by dam building, road building, channelizing, water diversion, diking for urbanization and agricultural practices, and timber harvest. All life stages are potentially affected by the alteration of hydrologic function in a system. While adults are affected by the changes in flow timing, eggs, juveniles and smolts may be affected by changes in seasonal cues and increases in water temperature and salinity. By changing the flow of water, sediment, nutrients, energy, and biota, dams and water diversions interrupt and alter most of a river's important ecological processes, and therefore most aquatic organisms living in the river. There are numerous dams and diversions that occur throughout the SONCC coho salmon ESU and these populations experience stress through a multitude of direct and indirect effects. More information on the effects of altered hydrologic function can be found in section 3.2.9 describing the impact of dams and diversions, as well as being described throughout the stress section where it is appropriately described. Altered hydrologic function is a high or very high stress (limiting factor) in 17 of 41 populations throughout the ESU (Table 3-4). The populations encountering the most severe stress (limiting factor) include the mainstem Klamath River populations, the Trinity River populations, Eel River populations, and tributary populations in all these basins, although other populations are impacted by water diversions and channel morphology changes that alter the hydrologic function in them as well.

The alteration of the hydrology of a basin can create both environmental and physical changes that affect salmon. Environmental changes include changes in timing and duration of high and low flows, alterations in temperature and dissolved oxygen levels, and changes in the occurrence of environmental cues. Physical changes from modified hydrology include aggradation of the stream channel, scouring of the stream bed, disconnection of channel and floodplains, and damage to riparian vegetation from flooding events. Habitat can be severely altered by floods, sometimes requiring decades to recover. During flood events, land disturbances resulting from logging, road construction, mining, urbanization, livestock grazing, agriculture, fire, and other uses may contribute sediment directly to streams or exacerbate sedimentation from natural erosive processes (California Advisory Committee on Salmon and Steelhead Trout 1988; California State Lands Commission (CSLC) 1993; FEMAT 1993). In some California streams, the pool-riffle sequence and pool quality still have not fully recovered from the 1964 regional flood. In fact, Lisle (1982) and Weaver and Hagans (1996) found that many Pacific coast streams continue to show signs of harboring debris flows from the 1964 flood. Such streams have remained shallow, wide, warm, and unstable. While legacy effects continue to impact coho salmon throughout the ESU, major strides need to be taken to begin working on the stresses (limiting factors) and threats that are likely to continue or exacerbate these mechanisms.

3.1.8 Barriers

Fish passage barriers in some way restrict the amount of available stream habitat on virtually all SONCC coho salmon rivers and are listed as a high or very high threat in seven out of 41 populations (Table 3-4). The most common types of barriers include road-stream crossings (e.g., culverts), dams, tidegates, and agricultural diversions (Volume II). Unscreened diversions in particular were mentioned at the time of listing as a threat to SONCC coho salmon and are still a concern today (CDFG 2004). Barriers can be inhibitive through the physical blocking of stream reaches (e.g., dams, sediment buildup, changes in gradient at tributary mouths, etc.) or through water temperatures that increase to such an extent that salmonids cannot pass through the area during a portion of the year (Richter and Kolmes 2003, McElhany et al. 2000). These thermal barriers can be created by the removal of riparian vegetation, the simplification of stream channels, or from climate change, while physical alterations are mostly created by anthropogenic changes in land use.

While many road-stream crossing structures and diversions have been upgraded with structures that are designed to accommodate fish passage, several hundred road-related barriers and unscreened diversions still exist throughout the ESU, blocking access to hundreds of miles of freshwater habitat (CalFish 2009, ODFW 2008). Many efforts are currently underway to improve or remove fish passage barriers in as many places as feasible. Large dams used for water storage or hydroelectric purposes have also eliminated high quality habitat that was once accessible to coho salmon, in addition to changing the hydrologic function. Efforts are being made around the ESU to remove or retrofit these structures, and return accessibility to previously blocked historic salmonid habitat. Dry stream reaches resulting from changes in stream flow, diversions, or channel aggradation can also present seasonal barriers to migration. The current lack of high quality habitat available within many populations has made the issue of barriers even more significant as many barriers block some of the highest quality habitat and remaining refugia within key watersheds.

Approximately 450 manmade total barriers are known to remain throughout the California portion of the ESU (CalFish 2009), and block access to historic spawning and rearing areas. Since the last status update, several significant fish passage improvements have occurred throughout the ESU. In the Rogue River, three dams were recently removed (Savage Rapids Dam in 2009, Gold Hill Dam in 2008, and Gold Ray Dam in 2010) and one was notched (Elk Creek Dam in 2008) to restore natural flow and fish passage. Although the Rogue River now flows unimpeded from the Cascade foothills to the ocean, there still remain several barriers on the mainstem Rogue, and dams are still a concern in the Rogue River Basin. Since 2005, 661 miles of stream have been opened to fish passage by removing 440 barriers (available at: http://www.dfg.ca.gov/fish/Administration/Grants/FRGP/index.asp). Overall, coho salmon passage has improved from the last status update, but barriers remain a major threat because many are still unaddressed and continue to block passage. More information regarding the direct and indirect effects of barriers can be found in other sections of this chapter and geographically-specific information can be found in each population profile (Volume II) where applicable.

3.1.9 Impaired Estuary/Mainstem Function

Estuarine habitats, including marshes, forested swamps, eelgrass beds, mudflats, and tidal channels, are vitally important to the life cycles of anadromous coho salmon (Koski 2009). As juveniles and smolts, coho salmon move from freshwater rearing habitats downstream into estuaries and the ocean. As adults, coho salmon return to these areas, moving upstream through the same interconnected habitats. Many estuaries and associated low gradient stream reaches have been physically altered and degraded. Impacts from changes in land use activities and other anthropogenic activities include decreases in the quantity and quality of estuary habitat, decreases in water quality from timber harvest, road construction, riparian vegetation removal, non-point source pollution, and changes in estuary productivity from alterations in nutrient levels and sediment supply (Bowen and Valiela 2001). Juvenile salmonids often utilize estuaries as rearing areas, but preferences vary with life history types and age of juveniles as they pass along the estuary gradient (Miller and Sadro 2003). In addition to estuaries, low energy, off-channel areas and flooded marshes (tidal channels, backwater sloughs, marshes, and swamps) appear to be important habitats and provide for a unique life history adaptation in many areas. These slow and backwater habitats are sites for the production and accumulation of organic matter that forms the basis for a macrodetrital food web, providing food for juvenile salmonids (Sibert et al. 1977). Additionally, lowland marshes in the brackish zone of estuaries are important habitat for salmonids as refuge and as feeding areas, while the fish adapt to a saltwater environment where they will spend most of their adult life (Iwata and Kotamtsu 1984, Macdonald et al. 1988, Cornwell et al. 2001).

Coho salmon habitat in many watersheds in the ESU has been affected by dikes and levees. These structures constrain and alter the natural hydrology, change instream channel morphology, and disconnect the channel from the surrounding floodplain. Dikes and levees are seen in many low gradient reaches throughout the ESU, and are often found in highly productive estuaries and off-channel areas.

For example, Redwood Creek is flanked for the first 3.4 miles by flood control levees that confine the channel to a 250-foot-wide channel migration zone, which bisects the estuary. The construction of this flood control levee resulted in extensive loss of estuarine area and decreases in habitat value (Cannata et al. 2006). Levees were also constructed along portions of the lower Van Duzen and Eel rivers to protect agricultural land and urban areas from flooding. Tideland reclamation and the construction of dikes and levees for agricultural purposes have changed the natural function of the Eel River estuary considerably. Slough and creek channels that once meandered throughout the Eel River delta are now confined by levees, sufficiently slowing flow to a point that many have become filled with sediment. Levees occur across the ESU, and impaired estuary/mainstem function results in a high to very high impact in 21 out of 41 SONCC coho salmon populations (Table 3-4). Loss and degradation of these habitats have significant impacts on populations that exhibit estuary rearing life history traits, because other adequate rearing and feeding areas may not exist or not be able to provide adequate conditions.

Global warming is expected to result in an acceleration of current rates of sea level rise, inundating many low lying coastal and intertidal areas. This could have important implications for organisms that depend on these sites. Galbraith et al. (2005) found that even assuming a conservative global warming scenario of 2ºC within the next century, there would be major

intertidal habitat losses at four out of the five study sites in the United States. These losses typically range between 20 percent and 70 percent of current intertidal habitat, and substantial areas of tidal flats would be lost in Humboldt Bay as soon as 2050 (Galbraith et al. 2005). The National Wildlife Federation looked at a range of climate change scenarios depicting differing heights of sea level rise to produce a forecast of impacts from sea level rise along the Pacific Northwest Coast of the United States. Results vary but overall the region will see a dramatic shift in the extent and diversity of its coastal marshes, swamps, beaches, and other habitats due to sea level rise. If global average sea level rise increases by 0.69 meters the following impacts are predicted by 2100 for the sites investigated:

Estuarine beaches will undergo inundation and erosion to the tune of 65 percent loss; as much as 44 percent of tidal flat will disappear; 13 percent of inland fresh marsh and 25 percent of tidal fresh marsh will be lost; 11 percent of inland swamp will be inundated with saltwater, while 61 percent of tidal swamp will be lost; 52 percent of brackish marsh will convert to tidal flats, transitional marsh and salt marsh; 2 percent of undeveloped land will be inundated or eroded to other categories across the study area (National Wildlife Federation (NWF) 2007). Changes in the composition of tidal wetlands could significantly diminish the capacity for those habitats to support salmonids (NWF 2007). Sea level rise will contribute to the expansion of open water in some areas – not just along the coast but inland where the water table has risen. Sea level rise will lead to significant beach erosion and make coastal areas more susceptible to storm surges. For example, estuaries and bays that experience a net loss in coastal marsh habitat are more likely to face declining water quality because marshes play a critical role in regulating nutrients and filtering pollutants. For a 27.3 inch increase in sea level rise, the area of swamp, and inland and tidal fresh marsh will decrease, while at the same time, the area of salt marsh will increase, and transitional marsh will expand (NWF 2007). Additionally, a recent analysis of sea-level rise in the Skagit Delta estimates that rearing capacity in marshes for threatened juvenile Chinook salmon would decline by 211,000 and 530,000 fish respectively, for a 45 and 80 centimeter sea level rise (Hood 2005).

3.1.10 Adverse Fishing-Related Effects

Historic Fishing Impacts

In the final rule to list SONCC coho salmon (62 FR 24588, May 6, 1997) overfishing was recognized as a contributing factor in the compromised escapement levels seen between 1950 and 1990. Exploitation of SONCC coho salmon is also expected to negatively influence recovery. Adult fish are of particularly high value to recovery because they have survived the stresses (limiting factors) and threats affecting egg, fry, juvenile, and smolt life stage and will soon reproduce. The number of fish arriving at a natal stream or river to spawn, or the spawning escapement, is critical to SONCC coho salmon recovery. Fishing regulations were changed to be more protective of coho salmon beginning in 1993, when the retention of coho salmon in ocean commercial fisheries was prohibited from Cape Falcon, Oregon (which is south of the Columbia River) to the U.S./Mexico border. The following year, coho salmon retention was prohibited in ocean recreational fisheries from Cape Falcon, Oregon to Horse Mountain, California, and expanded to include all California marine waters in 1995. Inland California waters were closed to fishing in 1998. These prohibitions remain in effect, with two exceptions: A mark-selective recreational coho salmon fishery in Oregon waters has occurred since 1998 at varying quotas

depending upon specified fisheries criteria, and tribal harvest has occurred under federal reserved fishing rights in the Klamath River and Eel River basins.

Federally Managed Fisheries

SONCC coho salmon are managed as part of the Oregon Coast Natural (OCN) stock aggregate, which includes coho salmon produced from Oregon river and lake systems south of the Columbia River and contribute primarily to ocean fisheries off Oregon and California (Pacific Fishery Management Council (PFMC) 1999). OCN coho salmon are part of a larger aggregate of natural and hatchery production south of Leadbetter Point, Washington known as the Oregon Production Index (OPI) (Sharr et al. 2000). SONCC coho salmon that migrate north of Cape Blanco, Oregon are vulnerable to incidental morality due to hooking and handling in the recreational ocean fishery targeting Chinook salmon. The extent of this mortality is estimated using hatchery-produced coho salmon stocked into the Rogue and Klamath rivers (R/K coho salmon).

The prohibition of retention of coho salmon, along with management of other fisheries to maintain acceptable incidental exploitation rates on coho salmon from other fisheries, led to consistently low exploitation rates after 1993 (Figure 3-1). Amendment 13 to the PFMC Pacific Coast Salmon Plan, which was adopted in 1997, was designed to ensure that fishery related impacts do not act as a significant impediment to the recovery of depressed Oregon Coastal Natural (OCN) coho stocks (Sharr et al. 2000). In contrast to previous management approaches, fishery management under Amendment 13 is based upon exploitation rates, not escapement targets. These exploitation rates are based upon estimates of habitat production potential that incorporate effects of both freshwater and marine environments and are derived from habitat-based assessment and modeling of OCN coho production (Sharr et al. 2000). Amendment 13 considers recovery of OCN stocks by ensuring sufficient spawner escapement to seed spawning habitat. A review of the effectiveness of Amendment 13 proposed more conservative allowable exploitation rates at very low levels of spawner abundance and marine survival and slightly higher rates when conditions of spawner abundance and marine survival are favorable (Sharr et al. 2000). This proposal was adopted by the PFMC (Kruzic 2011). In 1999, NMFS issued a biological opinion requiring that the overall annual ocean exploitation rate for R/K hatchery coho salmon remain less than 13 percent (NMFS 1999). PFMC adopted this limit, and since 1999 projected exploitation rates on R/K hatchery coho salmon have been considerably lower than 13 percent (Figure 3-1). Spawner escapement has accounted for a greater proportion of adult fish each year after 1993 than occurred before 1993 (Figure 3-2).

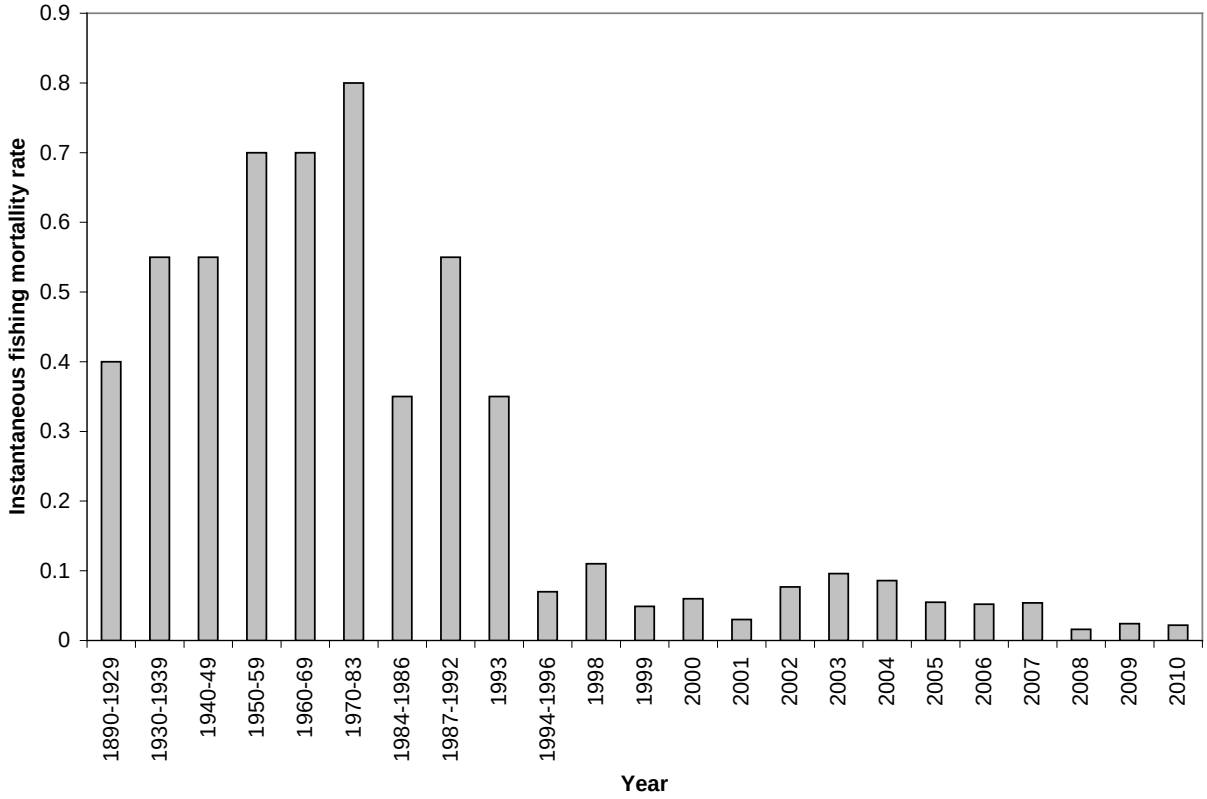

Figure 3-1. Estimated instantaneous fishing mortality rate on coho salmon in southern Oregon and northern California, 1890-2010. 1890 to 1996 rates on OCN stock aggregate are from ODFW 1997; 1998 rate is a preseason estimate for the OCN stock aggregate (PFMC 1999); 1999 through 2006 rates are pre-season estimates for Rogue/Klamath (R/K) coho salmon (PFMC 2000 to PFMC 2007, respectively); and 2007 through 2010 rates are preliminary post-season estimates for R/K coho salmon (PFMC 2008 to PFMC 2011, respectively)].

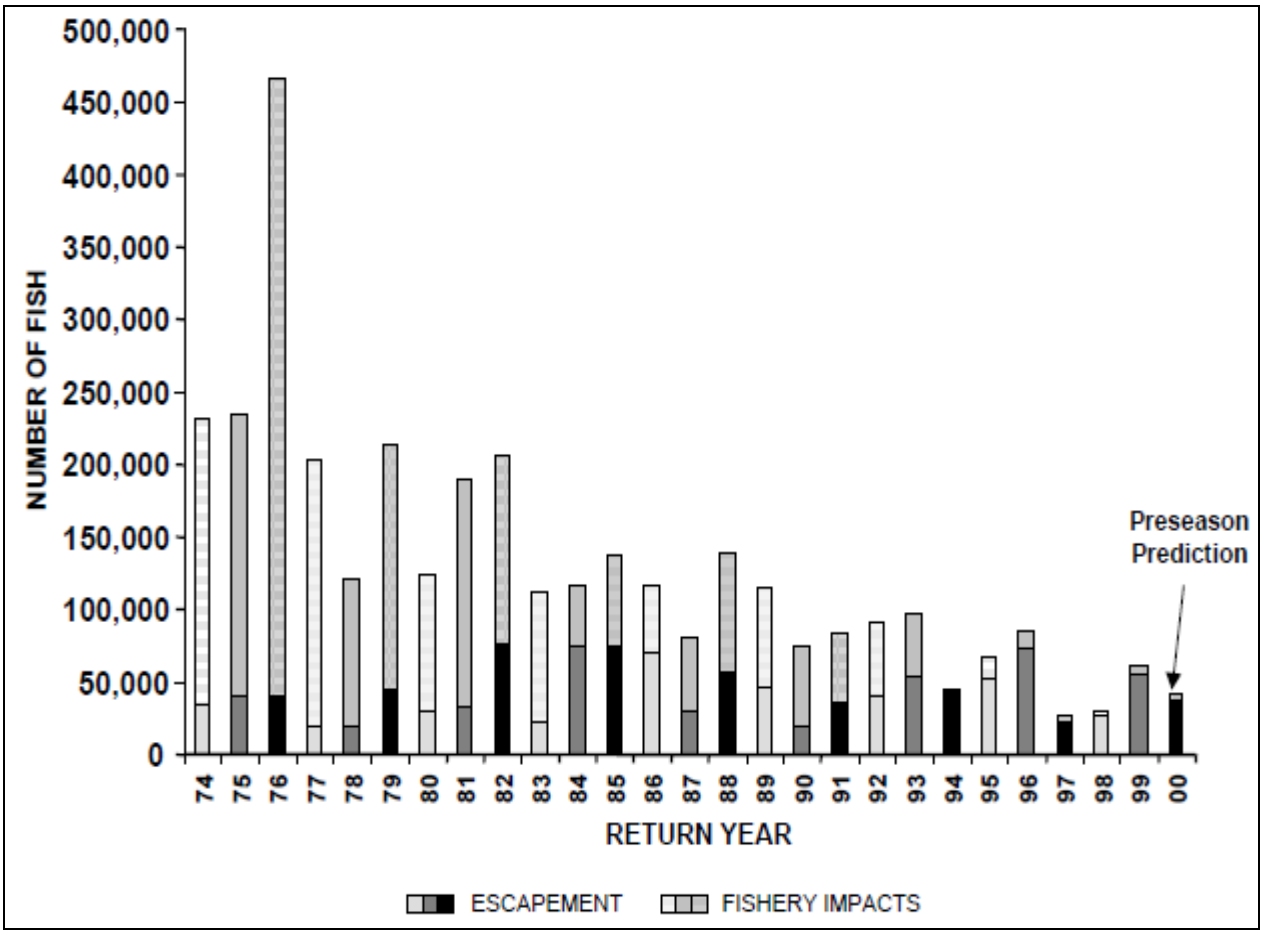

Figure 3-2. Total annual pre-fishery ocean population size of adult OCN coho, 1974 to 2000. (Figure from Sharr et al. 2000). The population for each return year is shown as stacked bars, with hatched portions depicting fishery-related impacts and solid portions depicting spawning escapement. The cohorts originating from the 1971, 72, and 73 brood cycles are depicted by light gray, gray, and black, respectively.

State-Managed Fisheries

In Oregon, adipose-fin-clipped coho salmon (hatchery coho salmon) can be retained when caught recreationally in state-managed waters (streams, rivers, tidewaters and bays), subject to areas-specific season and bag restrictions (ODFW 2011a). The 1999 NMFS biological opinion on the effects of federal fisheries on SONCC coho salmon also considered the effects of Oregon-managed fisheries on this ESU and required the exploitation rate in those fisheries to remain below 13 percent (NMFS 1999). NMFS (2007a) estimated that 3.3 percent of R/K hatchery coho salmon caught in this mark-selective fishery would die on release. Retention of coho salmon caught in any California-managed fisheries in the range of the SONCC coho salmon ESU is prohibited (CDFG 2011). The impact of California-managed fisheries on SONCC coho salmon has not been formally evaluated by NMFS.

Tribal-Managed Fisheries

The Yurok and Hoopa tribes have federally recognized fishing rights and pursue subsistence, ceremonial, and commercial fisheries for Chinook salmon and steelhead in the Klamath River basin (CDFG 2002a). Tribal harvest of coho salmon by these tribes is primarily incidental to Chinook salmon subsistence fisheries in the Klamath River and the Trinity River. The Karuk tribe uses dip nets to catch salmonids at Ishi Pishi Falls on the Klamath River. The Round Valley tribe holds a federally recognized right to pursue fisheries for salmon in the Eel River (Langridge 2002). The impact of in-river tribal fishing on the SONCC coho salmon ESU has not been formally evaluated by NMFS.

Fishing for coho salmon within the Yurok tribe's reservation on the Lower Klamath River, which extends from about 2 miles upstream of Weitchpec, California, to the Pacific Ocean, has been monitored since 1992. During that time the Yurok Tribe harvested about 70 percent of their catch below the Highway 101 bridge. The median Yurok harvest from the entire area from 1992 to 2009 was 418 coho salmon (Williams 2010), which approximates an average annual harvest of four percent of the total run. The total run size for the Klamath basin was determined by combining adult counts at the Trinity River, Iron Gate Hatchery, and Shasta and Scott river weirs (Williams 2010). On average, about 42 percent of the coho salmon harvested by the Yurok Tribe were progeny of coho salmon that spawned in the wild (Williams 2010). The effect of the Yurok fishery on particular populations within the SONCC coho salmon ESU is unknown, because all nine of the Klamath River basin coho salmon populations migrate through the lower Klamath River.

Trinity River coho salmon are harvested by the Yurok and Hoopa tribes. Table 3-7 describes the estimated percentage of the total run harvested by each tribe.

Table 3-7. Estimated number coho salmon harvested by Yurok and Hoopa tribes. Includes percentage of total adult run size harvested by Yurok and Hoopa tribes, from 1997 to 2008. M= Marked, U = Unmarked.

Year	Estimated Yurok harvest		Estimated Hoopa harvest[2]		Estimated total Trinity River adult run size[3]		Percentage total harvest taken by Yurok tribe		Percentage total harvest taken by Hoopa tribe	
	M	U[1]	M	U	M	U	M	U	M	U
1997	22	2	39	3	1,885	271	1.2%	0.7%	2.1%	1.1%
1998	117	6	88	54	10,285	1,297	1.1%	0.5%	0.9%	4.2%
1999	120	9	65	36	4,785	630	2.5%	1.4%	1.4%	5.7%
2000	70	1	211	22	10,586	386	0.7%	0.3%	2.0%	5.7%
2001	1214	111	506	100	28,139	3,389	4.3%	3.3%	1.8%	3.0%
2002	327	4	327	20	15,653	526	2.1%	0.8%	2.1%	3.8%
2003	121	23	85	17	22,963	4,352	0.5%	0.5%	0.4%	0.4%
2004	553	302	312	80	27,167	10,092	2.0%	3.0%	1.1%	0.8%
2005	640	24	153	21	27,947	2,856	2.3%	0.8%	0.5%	0.7%
2006	241	24	442	38	18,774	1,734	1.3%	1.4%	2.4%	2.2%
2007	61	17	68	14	4,436	1,257	1.7%	1.4%	1.5%	1.1%
2008	147	13	262	53	6,864	1,302	2.1%	1.0%	3.8%	4.1%
Median 1997-2008	134	15	182	29	13120	1300	1.9%	0.9%	1.7%	2.6%

[1] Calculated as follows: (Estimated harvest of marked Trinity River Hatchery (TRH) fish, provided by Yurok Tribal Fisheries Program) / estimated abundance of TRH coho salmon that migrated upstream of the Willow Creek weir) - estimated harvest of marked TRH fish. Jacks were excluded.
[2] Source: Hoopa Tribal Fisheries Program, unpublished data.
[3] Calculated as follows: Est. ocean incidental mortality[4] + Est. Yurok marked harvest + Est. Hoopa marked harvest + Est. recreational harvest upstream of WC weir (source: CDFG, unpublished data) + Est. recreational harvest downstream of WC weir (source: Hoopa Tribal Fisheries Program, unpublished data).
[4] Calculated as follows: (Est. Yurok marked harvest + Est. Hoopa marked harvest + Est. recreational harvest upstream of WC weir + Est. recreational harvest downstream of WC weir)* pre-season projected ocean incidental mortality rate (source: PFMC 2011).

Karuk fishermen are allowed by CDFG to catch salmon using dip nets at Ishi Pishi Falls on the Klamath River if they adhere to the same limits as Chinook salmon sport fishermen (CDFG 2002a). A Karuk tribe representative stated “its members rarely harvest more than 200 salmon and steelhead per year, that protected species such as coho salmon are never kept, and that these protected species are released alive” (Driscoll 2009).

Fishing Impacts

There are several reasons why the exploitation rates on SONCC coho salmon are expected to negatively influence recovery. Adult fish are of particularly high value to recovery because they

have survived the stresses (limiting factors) and threats affecting egg, fry, juvenile, and smolt life stage and will soon reproduce. Since the biological opinion was completed (NMFS 1999), NMFS has developed viability criteria for SONCC coho salmon, which are explained in this plan. Therefore, the viability criteria in this plan were not specifically considered in the biological opinion (NMFS 1999).

Collection for Research Purposes

Section 9 of the ESA prohibits 'take' of listed species. To take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (ESA Section 3(19)). When NMFS re-affirmed the listing of SONCC coho salmon in 2005 (70 FR 37160, 37196; June 28, 2005), NMFS identified collection or handling of fish among activities that may harm certain listed salmon ESUs and thus result in violation of the ESA Section 9 take prohibition.. Information on SONCC coho salmon populations is needed for the NMFS 5-year status reviews, as well as to determine the effectiveness of habitat restoration actions, and ultimately for de-listing. This information is derived from research studies of life history strategies, abundance, distribution, and genetics, and involves take of individuals.

Within the ESA, there are two mechanisms to enable listed fish to be taken for research purposes, and exempt the permit holder from the prohibitions of the ESA. Under Section 10(a)(1)(A) and NMFS implementing regulations at 50 CFR § 222.308 section 9, NMFS may issue permits for scientific research purposes or to enhance the propagation or survival of species listed as threatened or endangered under the ESA. The permitted activities must not operate to the disadvantage of the listed species and must provide a bona fide and necessary or desirable scientific purpose or enhance the propagation or survival of the listed species. NMFS traditionally issues permits for up to five years, although permits for longer periods of time have been issued.

NMFS regulations under ESA Section 4(d) of the ESA (50 CFR § 223.203(b)(7)), provide that take prohibitions for certain listed threatened species of anadromous salmonids, which includes SONCC coho salmon, do not apply to scientific research activities conducted by employees or contractors of certain state fish and wildlife agencies, including the California Department of Fish and Game and the Oregon Department of Fish and Wildlife, or as a part of a monitoring and research program overseen by or coordinated with that agency, if the agency meets specific requirements listed in these regulations.

Specific activities authorized for research purposes by either a permit issued under ESA section 10(a)(1)(A) or the ESA section 4(d) regulations described above may include: direct observation, capture (electrofisher, nets, trawls, and traps), handling, anesthetizing, marking, tagging, tissue sampling, and other activities necessary to conduct various studies to promote the conservation of the species, enhance the species' survival, or add significantly to the body of knowledge of SONCC coho salmon. The primary effects of these activities are in the form of harassment associated with intentional take. Harassment generally leads to stress and other sub-lethal effects and is caused by observing, capturing, and handling fish. Unintentional mortality may occur during handling or after the fish has been released. Depending on the activities and life stage, NMFS anticipates from one to five percent of handled fish may die. Permits may

include any conditions deemed necessary by NMFS, including reporting or inspection requirements for monitoring the impacts of permitted activities

Prior to issuance of either a permit under ESA section 10(a)(1)(A) or approval of a research program under the ESA section 4(d) regulations described above, NMFS must determine whether the action is likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat.

3.2 Threats

Threats are the activities or processes that have caused, are causing, or may cause the stresses (limiting factors) and thus the destruction, degradation and/or impairment of the focal conservation targets: SONCC coho salmon and their habitat. The major factors listed in 1997 as responsible for the decline of SONCC coho salmon were timber harvest, road building, grazing and mining activities, urbanization, stream channelization, dams, wetland loss, beaver trapping, water withdrawals and unscreened diversions for irrigation (62 FR 24588 May 6, 1997). Many of these continue to threaten coho salmon populations in this ESU while additional threats have emerged as significant factors that need to be addressed for recovery. An analysis of current threats has identified the following as currently contributing to the destruction, modification, or curtailment of habitat or range: timber harvest, roads, agricultural operations, urban/industrial/residential development, dams and diversions, fish passage barriers, channelization and diking, high intensity fire, disease/predation, adverse effects from hatcheries, invasive species, fishing and collecting, and mining and gravel extraction (See Volume II).

These threats have led to significant stresses on coho salmon populations throughout the ESU (Volume II) and have contributed to the decline of the species. The following threats (Table 3-8) occur throughout the ESU and are believed to be the main causes of the previously described stresses (limiting factors) (Table 3-4).

Table 3-8. Threat severity ranking by population.

	Threats													
Population	Climate change	Roads	Channelization/Diking	Agricultural Practices	Timber Harvest	Urban/Residential/ Industrial Development	High Intensity Fire	Mining/Gravel Extraction	Dams/Diversions	Invasive/ Non Native Alien Species	Hatcheries	Road Stream Crossing Barriers	Fishing and Collecting	Total High or Very High
Elk River	M	M	H	H	M	L	L	L	H	M	L	M	L	3
Lower Rogue River	M	VH	H	M	H	H	L	H	M	M	M	L	L	5
Chetco River	M	H	H	M	H	H	M	M	M	L	M	L	L	4
Winchuck River	L	M	H	M	M	H	M	M	H	M	NA	M	L	3
Hubbard Creek	L	M	M	M	M	M	L	NA	L	NA	NA	L	L	0
Brush Creek	M	VH	H	NA	M	L	L	NA	L	NA	NA	L	L	2
Mussel Creek	L	VH	VH	M	VH	H	L	NA	M	NA	NA	L	L	4
Hunter Creek	M	VH	VH	H	VH	H	M	L	M	L	NA	M	L	5
Pistol River	M	VH	VH	H	VH	M	M	L	M	NA	NA	L	L	4
Smith River	M	H	H	H	M	M	M	L	L	M	L	H	M	4
Lower Klamath River	M	H	M	H	H	M	L	L	H	L	L	L	L	4
Redwood Creek	M	VH	H	M	H	M	M	H	M	M	NA	L	L	4
Maple Creek/Big Lagoon	L	VH	M	L	VH	L	M	NA	M	L	NA	L	L	2
Little River	L	VH	M	H	VH	M	M	NA	M	NA	NA	L	M	3
Mad River	M	VH	H	M	H	M	M	H	M	NA	L	L	M	4
Elk Creek	L	M	H	M	M	H	L	NA	L	NA	NA	L	M	2

	Threats													
Wilson Creek	L	H	L	L	M	L	L	NA	L	NA	NA	L	M	1
Strawberry Creek	L	M	M	M	L	M	NA	NA	L	NA	NA	VH	M	1
Norton/Widow White Creek	L	VH	VH	M	M	VH	M	NA	M	L	NA	H	M	4
Humboldt Bay tributaries	M	VH	H	VH	VH	H	L	NA	M	M	L	L	M	5
Low Eel/Van Duzen Rivers	M	VH	H	H	VH	H	H	M	H	H	NA	L	M	8
Bear River	M	VH	L	H	VH	NA	M	L	L	NA	NA	L	M	3
Mattole River	M	H	M	M	H	H	H	L	VH	NA	NA	L	M	5
Guthrie Creek	L	M	L	M	H	L	L	NA	L	NA	NA	L	M	1
Illinois River	H	VH	H	H	H	M	M	H	VH	M	M	H	L	8
Mid. Rogue/Applegate Rivers	M	H	H	VH	H	VH	M	M	VH	M	M	M	L	6
Upper Rogue River	H	VH	H	VH	H	VH	L	H	H	M	M	M	L	8
Middle Klamath River	H	M	L	L	L	NA	H	M	M	NA	M	M	M	2
Upper Klamath River	H	VH	M	H	L	L	M	L	VH	L	VH	M	M	5
Salmon River	VH	M	NA	L	L	L	M	M	L	L	L	L	M	1
Scott River	VH	H	VH	VH	VH	M	H	M	VH	NA	L	L	L	7
Shasta River	H	H	H	VH	M	M	M	M	VH	NA	H	L	L	6
South Fork Trinity River	H	VH	L	M	L	L	M	L	H	L	M	L	M	3
Lower Trinity River	H	H	VH	ML	L	M	M	L	M	L	H	L	M	5
Upper Trinity River	H	H	M	M	L	M	M	L	H	M	VH	H	M	4
South Fork Eel River	M	VH	M	M	H	H	H	M	H	H	NA	H	M	7
Mainstem Eel River	H	VH	M	M	H	M	H	M	H	H	NA	M	M	6
Mid. Fork Eel River	H	VH	L	M	NA	M	H	NA	M	M	NA	M	M	3
Mid. Mainstem Eel River	H	VH	M	H	M	M	H	M	H	H	NA	L	M	6
Upper Mainstem Eel River	H	VH	NA	M	L	L	H	NA	VH	VH	NA	L	M	5

3.2.1 Climate Change

Climate change is having, and will continue to have, an impact on salmonids throughout the Pacific Northwest and California (Battin et al. 2007). While variations in model output exists, the overwhelming majority of climate models predict a warming trend resulting from rising levels of greenhouse gases in the atmosphere (Barnett et al. 2005). Population and ecological characteristics that influence vulnerability to climate change include snowpack reliance, current water temperature regime (e.g., how close to upper threshold levels are current water temperatures), the extent of barriers blocking access to cold water refugia, the range of intact ecological processes, and the current life history strategies and genetic diversity. For example, reduced genetic variability may limit the ability of individuals to adapt to changing climactic conditions. In addition, as climate change reduces the carrying capacity of the habitat within the range of SONCC coho salmon, species viability may be more difficult to achieve. The threat and stress (limiting factor) assessment included consideration of climate change and resultant environmental conditions. Although SONCC coho salmon have evolved and adapted to historic climate change, the currently low population numbers and existing poor environmental conditions are causing these climatic shifts to be increasingly worrisome (Battin et al. 2007). The declining abundance of SONCC coho salmon decreases the ability of the species to achieve viability. [Figure 3-3 and Figure 3-4] illustrate the relationship between climate variability and salmon stocks.

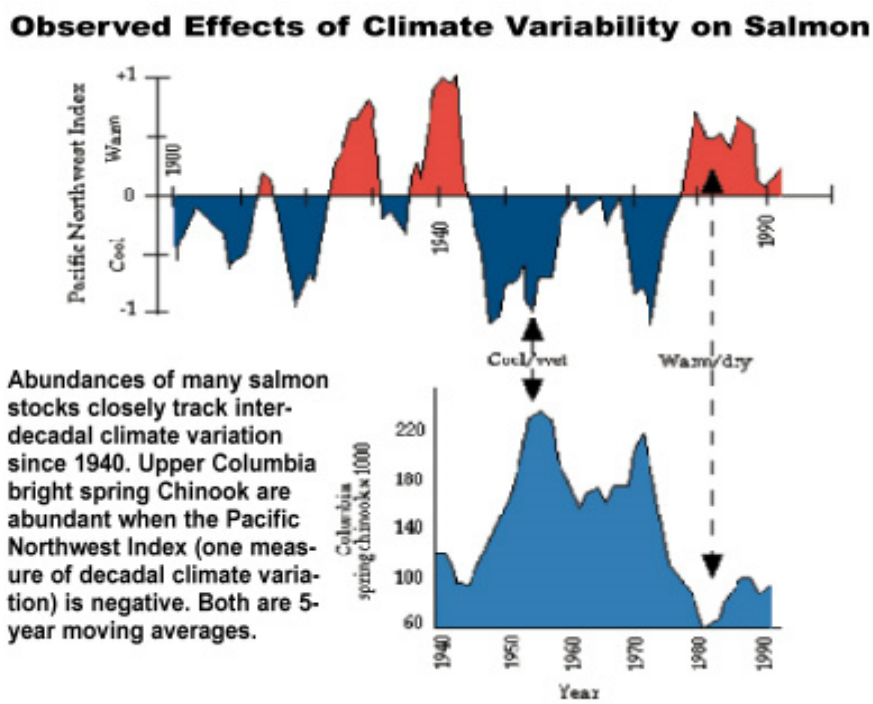

Figure 3-3. Observed effects of climate variability on salmon. Source: US National Assessment of the Potential Consequences of Climate Variability and Change, Educational Resources Regional Paper: Pacific Northwest. http://www.usgcrp.gov/usgcrp/nacc/education/pnw/pnw-edu-3.htm

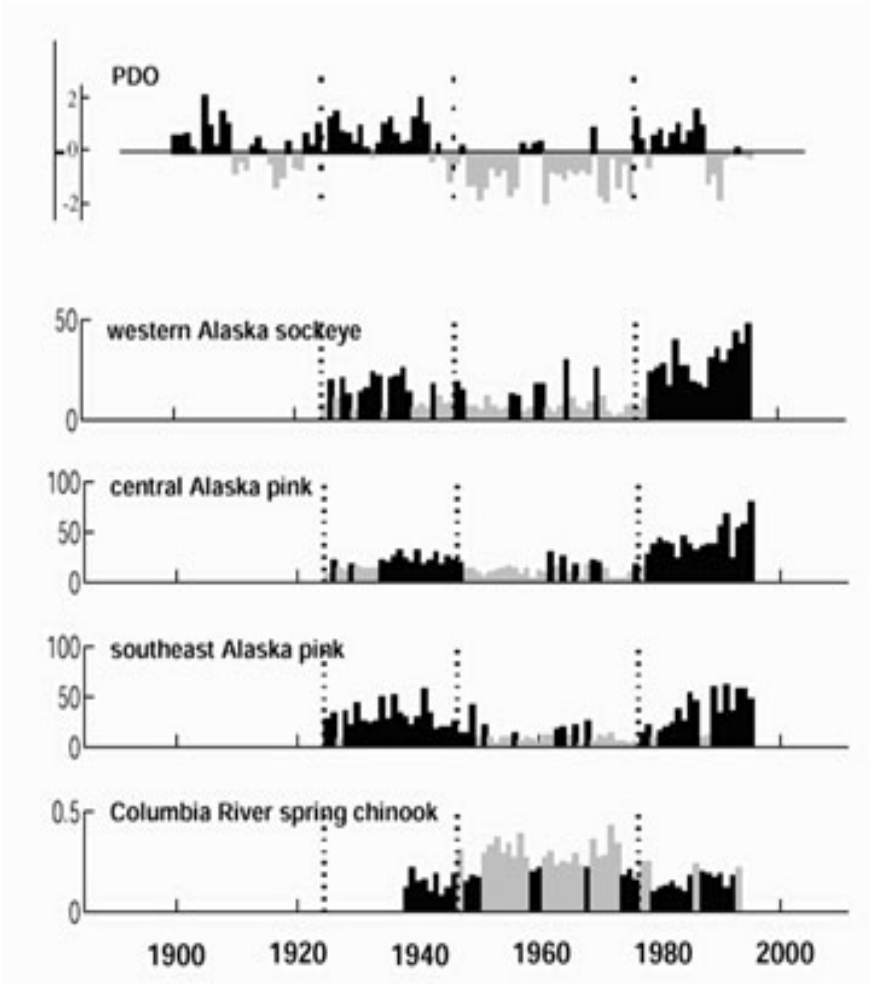

Figure 3-4. Salmon catches and inter-decadal climate variability. Twentieth century catches of Northwest and Alaska salmon stocks show clear influence, in opposite directions, of the Pacific Decadal Oscillation. Source: Mote et al (1999), Figure 36, p. 56.

Some of the effects of increased air temperature include changes in precipitation (amount of rain versus snow), the amount of snowpack, water quality (for example, temperature) and quantity (for example, more frequent, high intensity storms; and lower summer flows), and overall seasonal streamflow patterns (Bates et al. 2008). An increase in winter air temperature will result in the snowline moving up in elevation, and will thereby reduce the amount of water stored as snowpack. This will both result in higher winter runoff, and lower (and warmer) spring, summer and fall streamflows. In the Klamath Basin, Bartholow (2005) observed a 0.5 ºC per decade increase in water temperature since the early 1960s. As water temperatures rise, the amount of cold water refugia decreases.

Future climate change projections show that the impact of global warming on the western United States will include the reduction in the volumes and persistence of snowpacks across the region (Gleick 1987, Lettenmaier and Gan 1990), reduction in the fraction of precipitation that falls as snow rather than rain, and hastening of the onset of snowmelt once snowpacks have been formed (Knowles et al. 2006). In California, observations reveal trends in the last 50 years toward warmer winter and spring temperatures, a smaller fraction of precipitation falling as

snow, a decrease in the amount of spring snow accumulation in lower and middle elevation mountain zones, and an advance in snowmelt of 5 to 30 days earlier in the spring (Knowles et al. 2006). Higher atmospheric temperatures will also increase the ratio of rain to snow, shorten and delay the onset of the snowfall season, and accelerate the rate of spring snowmelt, which may lead to more rapid and earlier seasonal runoff relative to current conditions (Kiparsky and Gleick 2003).

Snow accumulation within the upper elevation of the SONCC coho salmon ESU acts as a natural reservoir by delaying runoff from winter months when precipitation is high, and shifts in climate will shift the timing and duration of releases from these natural reservoirs, altering instream conditions that salmon have evolved with (Kiparsky and Gleick 2003). Additionally, some newer General Circulation Models (GCMs), including those used in the National Weather Assessment, predict increases in California precipitation (Roos 2003), which may also cause shifts in flows and flood frequencies. These shifts will impact SONCC coho salmon populations by altering the timing of spring freshets, potentially increasing severity and quantity of flood events, increasing water temperatures, and altering the intensity of winter storms, thereby changing habitat accessibility, run timing, and egg development (Roos 2003). High flows associated with flood events can impact salmon through a variety of mechanisms, both beneficial and not. High flows and associated flooding are a natural process and can be beneficial to salmon and salmon habitat as a disturbance mechanism for scouring fine sediment from gravel, distributing large wood, recharging aquifers, allowing fish passage, transporting sediment and organic matter, and maintaining channel features (Lisle 1989). Conversely, high flows and flooding can cause the loss of eggs and alevins if they are scoured from the gravel or buried in sediment. Sedimentation of stream beds has been implicated as a principal cause of declining salmonid populations throughout their range and floods can result in mass wasting of erodible hill slopes and failure of roads on unstable slopes causing catastrophic erosion (Frissell 1992). Juveniles and smolts can be stranded by flood events, washed downstream out of rearing habitat, or washed out to sea prematurely. High flows can also prevent adults from reaching spawning areas.

Sea level rise is another effect of climate change, and will likely have a significant effect on estuaries and salmon habitat in low lying areas. Global mean sea-level rise is expected to reach between 14 and 44 cm within this century and is projected to inundate estuaries, and coastal wetlands, changing the amount and location of critical estuarine and brackish habitats for salmon. Rising sea levels will inundate wetlands and other low-lying lands, erode beaches, intensify flooding, and increase the salinity of rivers, bays, and groundwater tables (IPCC 2007). Some of these effects may be further compounded by other effects of a changing climate. Coastal wetland ecosystems, such as salt marshes and mangroves are particularly vulnerable to rising sea level because they are generally within a few feet of sea level (IPCC 2007). Many habitats such as wetlands, estuaries, and brackish marshes, which have been shown to be vital for salmon survival in some areas, will be physiologically altered, or completely cease to exist. Wetlands provide habitat for many species, play a key role in nutrient uptake, serve as the basis for many communities' economic livelihoods, provide recreational opportunities, and protect local areas from flooding. The IPCC suggests that by 2080, sea level rise could convert as much as 33 percent of the world's coastal wetlands to open water (IPCC 2007). Sea-level rise will also extend areas of salinization of groundwater and estuaries, resulting in a decrease in freshwater availability for fish and wildlife that inhabit these coastal areas (Kundzewicz et al. 2007). As a

result of sea level rise, low lying coastal areas will eventually be inundated by seawater or periodically over-washed by waves and storm surges. Coastal wetlands will become increasingly brackish as seawater inundates freshwater wetlands. New brackish and freshwater wetland areas will be created as seawater inundates low-lying inland areas or as the freshwater table is pushed upward by the higher stand of seawater (Pfeffer et al. 2008).

Coho salmon are sensitive to the above described changes in climate because they spend an extended period rearing in freshwater. Additionally, SONCC coho salmon are near the southern end of their distribution and often reside in streams already near the upper limits of their thermal tolerance. For these reasons, climate change poses a serious threat to the viability of SONCC coho salmon populations (NRC 2004). Changes in the climate across the landscape have been observed. While future climate predictions are forecasting increases in precipitation, many areas of the Pacific coast have experienced periodic drought conditions during much of the past 50 years, a situation that has undoubtedly contributed to the decline of many salmonid populations. Drought conditions reduce the amount of water available, resulting in reductions (or elimination) of flows needed for adult coho salmon passage, egg incubation, and juvenile rearing and migration (Bates et al. 2008). The drought conditions in the decade prior to listing were identified as a factor for listing and since that time, droughts have continued to affect coho salmon by creating poor spawning and rearing conditions. The spring of 2008 was listed as the driest on record for some areas of northern California, and 2001 and 2009 were “critically dry years. Additionally, the entire ESU experienced drought conditions during 2006 and 2007). Drought conditions may become more severe and more common as the climate continues to shift and seasonal changes become more pronounced. Additional changes in climate can be seen when looking at small scale regional weather characteristics, like the frequency of fog on the California coast. Data from 1901 to 2008 indicate that coastal temperatures have increased more than inland temperatures, accompanied by a reduced number of hours of coastal fog (Johnstone and Dawson 2010). If coastal fog continues to diminish there will be increased drought stress and potentially a reduction in the range of coast redwoods and associated fish and wildlife communities. In the coming years climate change will have an affect our ability to influence the recovery of some salmon species in most or all of their watersheds.

3.2.2 Roads

Roads are a pervasive feature throughout the ESU and reflect a legacy of land use activities. Nearly all populations that comprise the SONCC coho salmon ESU are affected by high road density, with some populations having greater than 10 miles of road per square mile. Roads are ranked as a high or very high threat in 33 populations. Roads can affect salmon populations by blocking migration, through interrupting and disrupting natural drainage patterns, increasing peak flow (Ziemer 1998), and increasing stream bed and bank instability (Chamberlin et al. 1991, McIntosh et al. 1994). Roads have been shown to impact spawning habitat, channel form, sediment inputs, and alter prey production. Additionally, roads placed immediately adjacent to watercourses can affect coho salmon through the removal of riparian vegetation, floodplain disconnection, and non-point source pollution inputs. Armentrout et al. (1998) used a reference of 2.5 mi/mi^2 of roads as a watershed management objective to maintain hydrologic integrity in Lassen National Forest watersheds harboring anadromous fish. Cederholm et al. (1981) found that fine sediment in salmon spawning gravels increased between 260 to 430 percent over background levels in watersheds with more than 4.1 mi/mi^2. Although some roads have been

decommissioned, there are still many miles of existing roads and maintenance is often lacking, leading to chronic impacts on habitat. Across the ESU, sediment from roads has contributed to decreased emergence survival, reduced carrying capacity for juvenile salmonids due to the filling of pools, channel simplification, and reduced feeding and growth due to high turbidity levels. Landslides triggered from road building related activities are large sources of sediment (Spence et al. 1996) and can create large scale episodic, mass wasting events that can severely impact a year class. Cederholm et al. (1981) reported that the percentage of fine sediments in spawning gravels increased above natural levels when more than two and a half percent of a basin area was covered by roads.

In addition to contributing fine sediment, roads can also affect water quality through the addition of heavy metal, gas, oil and other pollutants deposited on roads and subsequently washed into streams (Sandahl et al. 2007). These pollution inputs are difficult to remedy since they come from a variety of sources and can be spread out along the entire road length. Many pollution inputs occur during the winter months, which may have an effect on embryo and alevin salmon life stages, further decreasing survival and altering reproductive success.

Despite recent efforts to address impacts associated with = roads, there still remains inadequate funding for road maintenance and rehabilitation projects, inadequate regulations for maintenance and building on private roads, and a large number of existing problems associated with private and public roads throughout the ESU.

Plans Addressing Road Sediment

While management programs and plans to help alleviate effects from road development are lacking in many areas of the ESU, several counties within northern California have worked collaboratively to develop a comprehensive manual to guide road installation, maintenance, and remediation. To qualify their road programs under Limit 10 of the SONCC coho salmon 4(d) rule, Humboldt, Del Norte, Trinity, Siskiyou and Mendocino counties (Five Counties) collaboratively developed the “Water Quality and Stream Habitat Protection Manual for County Road Maintenance in Northwestern California Watersheds” (Five Counties Salmon Conservation Program 2002; hereafter referred to as “Manual”), which is based largely on the Oregon Department of Transportation (ODOT) Road Maintenance Handbook (ODOT 1999). The Manual includes design and construction guidelines and best management practices that minimize erosion and maintain or improve fish passage. This manual is the first to be developed in California and represents a collaborative effort in addressing road maintenance impacts on coho salmon. Since 1998, the Five Counties effort has assessed and prioritized 245 road crossings for repair or replacement, using the biological needs of salmonids as their main driving factor. This program has repaired or replaced 56 road culverts, improved or enabled access to 137 miles of fish habitat, and completed Road Erosion Inventories on over 2,000 miles of road (Five Counties Salmonid Conservation Program 2010). In 2007, NMFS approved the Five Counties’ Manual under the 4(d) rule.

Similarly, ODOT’s *Routine Road Maintenance Water Quality and Habitat Guide Best Management Practices* (ODOT 1999) is utilized across the state of Oregon to identify and implement measures, or best management practices, that minimize potential environmental impacts associated with ODOT activities. In California, the state transportation agency

(Caltrans) utilizes the *Caltrans Storm Water Quality Handbook*, and *Construction Site Best Management Practices Manual* to provide contractors and Caltrans staff with detailed information of construction site BMPs. These documents allow for road and transportation related projects to be implemented while minimizing effects to fish and wildlife.

Other important programs to address road-related sediment issues include the Northwest Forest Plan for land administered by U.S. Forest Service and Bureau of Land Management, and the Habitat Conservation Plans (HCPs) for land managed by Humboldt Redwood Company and Green Diamond Resource Company, the two largest private timber companies within the SONCC coho salmon ESU. Information about these programs is included in Section 1.2.4.

3.2.3 Channelization and Diking

NMFS identified stream channelization and diking as threats at the time of listing SONCC coho salmon, and remain a threat today in approximately 50 percent of the populations. Diking and channelization are especially prominent in the low-lying areas of most watersheds (Ricks 1995). Diking leads to the direct loss of habitat through disconnection of channel, floodplain, and wetland habitat and contributes to the loss of connectivity and hydrologic function. Channelization often occurs in association with agriculture and development and leads to the simplification and degradation of habitat (Kukulka and Jay 2003). Channelization and diking associated with flood control and agriculture reduces habitat, limits stream complexity, and increases stream velocities, which can be detrimental to both adult and juvenile coho salmon (May et al. 1997). Stream reaches have been channelized and diked to aid in the conversion of land from forest and riparian to agricultural, industrial and urban land use. In nearly all the lowlands and estuaries within the ESU, the majority of historic floodplain and off-channel habitat were diked for agriculture purposes and flood protection (Chapman and Knudsen 1980). In many upstream areas, floodplain and riparian habitats were disconnected from the channel for the construction of homes and industrial facilities, further impacting watercourses and channel morphology. Channelized reaches often lack floodplain connectivity and riparian vegetation, rarely contain complex habitat features such as pools, and experience high flows and degraded water quality (Ricks 1995). These areas provide little if any rearing or spawning habitat and can contribute to degraded water quality and hydrologic function within the watershed.

For example, Redwood Creek is flanked for the first 3.4 miles by flood control levees that confine the channel to a 250-foot-wide channel migration zone, which also bisects the estuary. This levee has resulted in profound loss of estuarine area and habitat value (Cannata et al. 2006). Levees were also constructed along portions of the lower Van Duzen and Eel rivers to protect agricultural land and urban areas from flooding. Tideland reclamation and the construction of dikes and levees for agricultural purposes have changed the natural function of the Eel River estuary considerably. Slough and creek channels that once meandered throughout the Eel River delta are now confined by levees, sufficiently slowing flow to a point that many have filled with sediment.

3.2.4 Agricultural Practices

Conversion of many lowland areas to agricultural use has dramatically altered the form and function of streams and their riparian corridors. In addition, irrigated agriculture and livestock

grazing also negatively impacts coho salmon habitat (Nehlsen et al. 1991) and directly impacts juvenile coho survival and fitness. Agricultural operations located immediately adjacent to watercourses and stream channels have degraded habitat and limited both water quality and quantity through the filling and diking of wetlands, installation of irrigation diversions, channelization, grazing in riparian areas, compaction of soils in upland areas, and indirectly through the use of pesticides and fertilizers (Botkin et al. 1995, Spence et al. 1996). A large proportion of estuaries and floodplains have been converted to agricultural land through the diking and filling of floodplain habitat (see section 3.2.3). The loss of these areas has had major impacts on the form and function of watersheds and their ability to support salmon, especially juvenile coho salmon, which require diverse, complex rearing habitats and floodplain connectivity.

One of the major stresses (limiting factors) associated with agricultural practices has been the diversion and consumptive water use on many streams, which has led to reduced stream flows in the summer and fall, including seasonal loss of surface flow in some streams. Water is the most essential component of fish habitat; without adequate water, coho salmon cannot survive. Water diversions can cause fragmented habitats and increase stream temperatures while impeding the geomorphological processes that maintain stream health (Cone and Ridlington 1996). Decreased water availability can create stressful situations for salmonids, and can decrease fitness and survival of juveniles rearing in areas with degraded water quality (Bjornn and Reiser 1991). For instance, water use in the Scott River Valley, California, has been associated with reductions in summer and fall base flows (Van Kirk and Naman 2008), which has been cited as a limiting factor in coho salmon production in this system (NRC 2004). Consumptive water use has also lowered the water table near affected streams, which has limited the ability of riparian plant species to proliferate and contributes to low flow barriers. In some areas, seasonal and permanent dams are constructed to provide water for agricultural operations and have resulted in altered stream function, migration barriers, changes in stream temperature, and temporary increases in sedimentation.

Agricultural practices can result in the degradation or elimination of riparian areas. Within many riparian areas, the vigor, composition, and diversity of natural vegetation have been, and continue to be, altered by livestock grazing and agriculture. This in turn has affected the ability of riparian areas to control erosion, provide stability to stream banks, and provide shade, cover, and nutrients to the stream (Mundy 1997). Mechanical compaction in riparian and upland areas has reduced the productivity of the soils appreciably and caused bank slough and erosion (Bellows 2003). Mechanical bank damage often leads to channel widening, lateral stream migration, increases in water temperature, and sedimentation (Scholz et al. 2000).

Agricultural practices are also a key producer of non-point-source pollution including nutrients and sediments, which can enter streams with runoff from livestock areas or cultivated fields, and agricultural chemicals. Risk to coho salmon resulting from agriculture chemical use has been identified as a concern throughout the Pacific Northwest (Laetz et al. 2009), and it is likely that pesticides known to harm salmonids (NMFS 2008b) are used within the SONCC coho ESU. For example, herbicide use has resulted in fish kills in the Rogue River basin, including juvenile coho salmon in Bear Creek in 1996 (Ewing 1999).

Agricultural Regulations

Historically, the impacts to fish habitat from agricultural practices have not been closely regulated. Oregon's Agricultural Water Quality Management Act, also known as Senate Bill 1010, was enacted in 1993 (requirements are currently codified at Oregon Revised Statutes 568.900 to 568.933), and is the basis for the Oregon Department of Agriculture's Agricultural Water Quality Program, which includes Agricultural Water Quality Management Area Plans (see Oregon Administrative Rules Chapter 603, Divisions 90 and 95). Although these plans are intended to reduce the impacts of agricultural practices on water quality, progress have been insufficient and state water quality standards are still unmet. The state of California does not have regulations that directly manage agricultural practices, but relies on the TMDL process to improve water quality from all applicable parties. See section 3.1.2 for more information on the TMDL process. The TMDL process is one way that the federal government, through state agencies, are able to regulate the amount of pollutants and other contaminants that enter a watercourse.

Another more direct federal regulation is the registration of fertilizers and pesticides by the Environmental Protection Agency (USEPA). USEPA has established a program to monitor and regulate pesticides and other chemicals that may harm listed species (Washington State Department of Agriculture (WSDA) 2010). USEPA has accomplished this through the implementation of a pesticide registration and registration review program for a suite of chemical fertilizers used across the United States. USEPA's strategy is to address listed species concerns within the context of the pesticide Registration and Registration Review process. The intent of this program is to provide appropriate protection to listed species and their critical habitat from pesticides while avoiding unnecessary burden on pesticide users and agriculture (WSDA 2010). In order to address the ESA during the pesticide Registration and Registration Review process, USEPA developed the Endangered Species Protection Program (ESPP). The ESPP requires refinements to geographic and biological components of the ecological risk assessment as they apply to listed species. The USEPA may use Bulletins to mitigate risk to listed species either prior to initiation of consultation or as a mechanism to implement Reasonable and Prudent Alternatives (RPAs) and Reasonable and Prudent Measures (RPMs) identified through consultation with the Services (WSDA 2010).

As risks to listed species are identified through either the USEPA registration process or consultation with the NMFS and U.S. Fish and Wildlife Service, USEPA issues Endangered Species Protection Bulletins (Bulletins) that specify mitigation or protective measures. Bulletins describe specific geographic areas within individual U.S. counties where use limitations exist. When needed, Bulletins are referenced in pesticide label statements that inform users the product may harm a threatened or endangered species or their critical habitat (WSDA 2010). The use limitations specified in Bulletins are supplemental label language enforceable for the county specified.

3.2.5 Timber Harvest

Substantial timber harvest has occurred throughout the ESU. Timber harvest is ranked as a high or very high threat in 22 populations (Table 3-8). In many of these populations, while timber harvest activity has decreased since the peak over 50 years ago, and practices and management

have improved, the effects of future timber harvest continues to be a potential threat to coho salmon. In many streams, logging in the riparian areas has resulted in reduced inputs of leaf litter, terrestrial insects, and large wood (Reeves et al. 1993, Nakamoto 1998,). Reduction of large wood from the harvest of streamside timber has resulted in the reduction of cover and shelter from turbulent high flows, and large wood needs to be reintroduced wherever possible (Cederholm et al. 1997). The threat from future timber harvest lies in the inability of already damaged landscapes to rebound from continued impacts, and if detrimental timber harvest (i.e., clear cutting, decreased age of trees removed) continues, cumulative effects and large scale, landscape size problems will begin to occur on a more regular basis. Renewing or continuing harmful logging practices will result in decreased cover, reduced storage of gravel and organic debris, and will likely result in continued loss of pool habitat and a reduction in overall hydraulic complexity (CDFG 2002a). While harmful logging practices have been shown to be detrimental to salmon populations, new logging methods that promote stand diversity, thin overcrowded plantations, and help restore fire-damaged lands must be implemented to provide an active recovery for damaged systems throughout the ESU. Appropriate timber harvest can, and will, aid in the re-establishment of riparian vegetation, sediment storage, and stand diversity, all ecosystem characteristics that are beneficial to salmonid populations.

By altering hydrology and slope stability, timber harvest can increase the amount of fine sediment delivered to streams and impair water quality. There is a strong relationship between the percent of a watershed harvested in the past 15 years and the duration of stream turbidity exceeding thresholds of salmonid feeding impairment (Klein et al. 2008). Timber harvest reduces the amount of precipitation intercepted by vegetation, resulting in increased peak flows during storm events (Grant 2010). Increased peak flows have only been detected during storms with a return period of 6 years or less (Grant 2010), and the effect diminishes over time as vegetation recovers (Keppeler et al. 2003). Long-term paired watershed studies in Caspar Creek on the Mendocino Coast, where road-related erosion is only a minor contributor to sediment, found that despite robust riparian buffer strips, increased peak flows induced by timber harvest increased gully erosion in small stream channels, expanding drainage networks and contributing significantly to suspended sediment yields (Reid et al. 2010). Timber harvest can also affect slope stability and increase the frequency of shallow landslides. Studies on the Oregon Coast found reduced root strength in clear cuts and industrial forests relative to old-growth conifer forests (Schmidt et al. 2001), and that shallow landslides tended to occur in localized areas with reduced root strength such as gaps in the root network between large trees or in areas lacking large trees (Roering et al. 2003).

One of the greatest continuing stresses from past timber harvest is the residual effects of increased input of fine sediment into streams. This impact does not cease when timber harvest activities are complete, but instead continues a legacy of negative effects that begin anew during each winter storm event or high flow. Road building and other timber harvest activities have resulted in mass wasting and surface erosion that will continue to elevate the level of fine sediments in spawning gravels and fill the substrate interstices inhabited by invertebrates (Platts et al. 1989, Suttle et al. 2004). Changes in channel morphology will continue to alter the hydrology and timing of flows in areas affected by these chronic events. Bisson et al. (1997) estimated that, due to anthropogenic activities such as logging, the frequency of major floods was 2 to10 times greater, debris flows and dam-break floods were 5 to 10 times more frequent, and slumps and earth flows were 2 to 10 times more frequent, than natural, background

conditions. This increase in catastrophic events will continue to dramatically alter the conditions in which coho salmon spawn and rear and cause a reduction in food supply, reduced quality of spawning gravels, and an increased severity of peak flows during heavy precipitation. Additionally, the continued removal of riparian canopy cover from these events will result in increased solar radiation, which will create further increase in water temperature (Spence et al. 1996).

USFS and BLM Land Resource Management Plans

The Northwest Forest Plan (NWFP) is a comprehensive ecosystem management strategy for Federally managed lands administered by the U. S. Forest Service (USFS) and Bureau of Land Management (BLM) within the range of the northern spotted owl (USDA-FS and USDI-BLM 1994). Approximately 53 percent of the land area within the SONCC coho salmon ESU is managed under the NWFP. Over 70 percent of the land in the Trinity River basin is managed by the USFS, and within that area, about 85 percent is designated as critical habitat. Additionally, within the Six Rivers National Forest, which is within the NWFP jurisdiction, there are four independent SONCC coho salmon populations, and public lands account for 75 percent of the population areas.

A primary component of the NWFP, the Aquatic Conservation Strategy (ACS), was designed to protect salmon and steelhead habitat on federal lands managed by the USFS and BLM by maintaining and restoring ecosystem health at watershed and landscape scales (NMFS 1997). The ACS contains nine objectives that describe general characteristics of functional aquatic and riparian ecosystems, and these objectives are intended to maintain and restore good habitat in the context of ecological disturbance. The ACS is intended to prevent further degradation of aquatic ecosystems and restore habitat over broad landscapes (Lanigan et al. 2011). While the NWFP covers a very large area, the overall effectiveness of the NWFP in conserving Oregon and California coho salmon is limited by the extent of USFS and BLM federal land ownership, which is not uniformly distributed in watersheds within the ESU. However, where administered, the NWFP has made improvements on the landscape through better management of both timber harvesting and road maintenance and construction. A report by Lanigan et al. (2011) documented trends in watershed, riparian and upslope condition throughout the area of the NWFP. Ten percent of watersheds displayed a positive change in indicator categories, with these changes attributed to the combined effects of natural vegetation growth, and road decommissioning. A greater proportion of positive changes in watershed condition occurred on late-successional reserve (LSR) and matrix lands than on congressionally reserved lands (e.g., wilderness areas and national parks), which were already in good condition (Lanigan et al. 2011). Declines in watershed condition were seen in some areas, with declines attributed to the Biscuit Fire of 2002, and other fire complexes that occurred during the 15 years of the study. Overall road density changed only slightly across the area of the NWFP; however, dramatic changes were accomplished in targeted watersheds. For example, road density in Lower Fish Creek in the western cascades declined from 3.3 mi/mi^2 in 1994 to 0.8 mi/mi^2 in 2008 through the decommissioning of 118 miles of roads (Lanigan et al. 2011). Overall, Lanigan et al. (2011) stated that road decommissioning in landslide prone areas provided the most benefits.

Although public lands tend to be located in the upper reaches of watersheds or river basins, and upstream of the highest quality coho salmon habitat, the above mentioned report documents that

efforts made by both the USFS and BLM through the NWFP have begun to improve coho salmon habitat, and provided improved water quality conditions starting in headwater areas. In other areas, public lands are distributed in a checkerboard fashion, resulting in fragmented landscapes that are more difficult to improve.

State Forest Practices Acts

State Forest Practices Acts (FPAs) in both Oregon (1971) and California (1973) along with their associated forest practice rules (FPRs) were designed to promote the continuous economic activity of growing and harvesting forest trees while meeting federal and state environmental standards, rules, and regulations (e.g., CWA, ESA). The FPAs and FPRs apply to all non-federal forestland, including private, state-owned and local, government-owned forestlands. Because of the preponderance of private timberland and timber harvest activity in the range of this ESU, and potential adverse effects, careful consideration of state forest practices rules and regulations is prudent. At the time of listing, most reviews of the FPRs indicated that implementation and enforcement of these rules did not adequately protect coho salmon or their habitats (CDFG 1994, Murphy 1995). FPAs and FPRs in both Oregon and California continually go through reviews and the regulatory agencies receive recommendations for improved aquatic habitat protection. Neither has fully adopted recent recommendations, and both remain inadequate for the complete protection of salmon in the SONCC coho salmon ESU. Although the FPRs have a requirement for disapproval of Timber Harvest Plans that would result in a 'taking' or finding of jeopardy for listed species (14 CCR § 898.2(c)), the rules do not explicitly describe the method for effectively implementing this requirement.

In 1997, at the time of the original listing of SONCC coho salmon ESU (62 FR 24588, May 6, 1997), timber harvest was identified as a significant threat to the species and their habitat. Specifically, NMFS identified inadequacies of the FPRs to address large wood recruitment, streamside tree retention, canopy retention standards, monitoring of timber harvest operations, and salvage logging. In July 2000, CDF adopted interim *Threatened or Impaired Watershed Rules* (T&I rules) to protect and restore watersheds with threatened or impaired values. The T&I rules were intended to minimize impacts to salmonid habitat resulting from timber harvest by requiring special management actions in watersheds with either state or federally listed threatened, endangered or candidate populations of anadromous salmonids present or where they can be restored. Examples of special management actions required by the T&I rules include constructing watercourse crossings that allow for unrestricted fish passage, increasing large wood recruitment, and increasing soil stabilization measures. The T&I rules also required coordination between CDF and the State and Regional Water Quality Control boards to minimize sediment discharge. The Board of Forestry (BOF) never permanently adopted the T&I rules. Rather, the BOF readopted the T&I rules six times subsequent to 2000. The T&I rules expired in December 2009, and the Anadromous Salmonid Protection (ASP) rules replaced them in 2010. The BOF's primary objectives in adopting the ASP rules were to: (1) ensure rule adequacy in protecting listed anadromous salmonid species and their habitat, (2) further opportunities for restoring the species' habitat, (3) ensure the rules are based on credible science, and (4) meet Public Resources Code (PRC) § 4553 for review and periodic revisions to the forest practice rules (FPRs).

NMFS staff have actively engaged and participated in BOF meetings and expressed concern to the BOF that the ASP rules, while resulting in some improvements to riparian protections, would not adequately protect anadromous salmonids until several inadequacies in the FPRs are addressed. Specifically, take of listed salmonids resulting from timber harvest operations in California could be minimized (but not entirely avoided) if the following protections were added to the existing ASP rules: (1) provide Class II-S (standard) streams with the same protections afforded Class II-L (large) streams, (2) include provisions to ensure hydrologic disconnection between logging roads and streams, and (3) include provisions to avoid hauling logs on hydrologically connected roads during winter periods. In addition, NMFS believes the use of scientific guidance will provide additional limitations on the rate of timber harvest in watersheds to avoid cumulative impacts of multiple harvests, and provide greater protections to ensure the integrity of high gradient slopes and unstable areas. This may include limiting the areal extent of harvest in such areas.

ASP rules do not apply where there is an approved Habitat Conservation Plan (HCP) that addresses anadromous salmonid protection; a valid Incidental Take Permit (ITP) issued by DFG; a valid Natural Community Conservation Planning (NCCP) permit approved by DFG; or project revisions, guidelines, or take avoidance measures pursuant to a Memorandum of Understanding (MOU) or a planning agreement between the plan submitter and DFG in preparation of obtaining a NCCP that addresses anadromous salmonid protection. These rules also do not apply to upstream watersheds where permanent dams block anadromy and reduce the transport of fine sediment downstream, or watersheds that do not support anadromy and feed directly into the ocean.

The California FPRs (BOF 2011) include an Article 6 on Watercourse and Lake Protection under the Coast, Northern, and Southern Forest District Rules subchapters, and the section on Intent of Watercourse and Lake Protection (14 CCR §§ 916, 936, and 956) under this Article and each of these subchapters provides, in relevant part:

> The purpose of this article [6] is to ensure that timber operations do not potentially cause significant adverse site-specific and cumulative impacts to beneficial uses of water, native aquatic and riparian-associated species, and the beneficial functions of riparian zones; or result in an unauthorized take of listed aquatic species; or threaten to cause violation of any applicable legal requirements. This article also provides protective measures for application in watersheds with listed anadromous salmonids and watersheds listed as water quality limited under Section 303(d) of the Federal Clean Water Act.

It is the intent of the BOF to restore, enhance and maintain the productivity of timberlands while providing appropriate levels of consideration for the quality and beneficial uses of water relative to that productivity. Protections include: guidelines for the removal of debris and soil, prohibition of road construction, prohibition of use of tractor roads, requirements to comply with TMDLs, objectives for streamside bank protection, riparian buffers, and providing appropriate shading.

In summary, NMFS is working collaboratively with the BOF to limit the effects of forestry operations on threatened and endangered salmonid populations in California, including the

SONCC coho salmon ESU. At this time, however, the effects of past and present timber harvest activities in California continue to be an ongoing threat to the ESU.

The Oregon Forest Practices Act (OFPA), while modified in 1995 and improved over the previous OFPA, did not have implementing rules that adequately protected coho salmon habitat at the time of listing. In particular, the OFPA did not provide adequate protection for the production and introduction of large wood to medium, small and non-fish bearing streams. Since the listing of SONCC coho, the Oregon Plan for Salmon and Watersheds (Oregon Executive Order 99-01; 1999) has directed the creation of the Forest Practices Advisory Committee (FPAC) to help the Oregon Board of Forestry assess forest practices changes that may be needed to meet state water quality standards and protect and restore salmonids. As of 2003, draft water protection rules and non-regulatory recommendations based on the recommendations of FPAC had been developed but had not been adopted by the Board of Forestry. A review of Oregon's FPA and FPRs (IMST 1999) showed the regulations in place may be ineffective at protecting water quality and promoting riparian function and structure, especially in small- and medium-sized streams. In their review of the FPRs, the Oregon IMST (1999) found that one of the greatest shortcomings of the current rules is that they are dominated by site- and action-specific strategies which taken together are insufficient for salmon recovery.

Habitat Conservation Plans

Two habitat conservation plans (HCPs) within the range of SONCC coho salmon have been finalized, and have enhanced management of private timberlands in northern California. Finalized in 1999 and valid through 2049, the Humboldt Redwood Company (HRC) HCP (formerly PALCO HCP) covers approximately 210,000 acres of industrial timberlands in northern California and includes activities related to timber management, forest road construction and maintenance, and rock quarrying (Palco 1999). The major watersheds covered by the HRC HCP include portions of Freshwater Creek, Elk River, Eel River, Van Duzen River, and the Mattole River. The HRC HCP is habitat-based, having a defined goal of achieving or trending towards properly functioning aquatic conditions. This HCP relies heavily on watershed analysis, monitoring, and adaptive management tools to ensure achievement of habitat goals. The most recent HRC HCP monitoring report (HRC 2009) indicated that approximately 44 percent of habitat objectives in the HCP are being met, a 4 percent improvement since 2002, and a 3 percent improvement since 2008.

Finalized in 2006 and valid through 2056, the Green Diamond Resource Company HCP applies to approximately 410,000 acres in coastal northern California. This HCP includes portions of all coastal coho salmon population areas from the Oregon border south to, and including, the Eel and Van Duzen rivers (Green Diamond 2006). The HCP calls for removing 50 percent of the high and moderate priority road sites within the first 15 years of plan implementation. These measures, coupled with provisions for riparian protection, mass wasting avoidance, and adaptive management ensure that adverse impacts to coho salmon rearing, migration, and spawning habitats are minimized or avoided. The first biennial report for the Green Diamond HCP was submitted to NMFS in 2009 (GRDC 2009). In the report, Green Diamond focused primarily on laying a foundation for future monitoring efforts, and reported baseline environmental conditions (e.g., turbidity levels, stream temperatures) for future comparison. At this time, it is not possible

to evaluate changes in coho salmon habitat conditions resulting from HCP implementation, and probably will not be for at least another 10 to 15 years.

3.2.6 Urban/Residential/Industrial Development

Substantial development and urbanization has contributed to habitat impairment through the ESU and 15 populations of SONCC coho salmon currently have development ranked as a high or very high threat (Table 3-8). Although most of the range of the SONCC coho salmon ESU is considered to be rural, there are three highly urbanized population centers. The Humboldt Bay and Yreka areas in California and the Medford/Grants Pass area in Oregon all have urban centers with high percentages of impervious surfaces that contribute to the degradation of habitat and coho salmon viability. Development and urbanization often leads to degraded habitat through stream channelization, floodplain disconnection, damage or loss of riparian and wetland areas, point and non-point source pollution, bank hardening, and consumptive water use (Botkin et al. 1995). When watersheds are developed, natural vegetative ground cover is removed and/or replaced by impervious surfaces or structures, water infiltration is reduced and runoff from the watershed is flashier, with increased flood hazard (Leopold 1968). Flood control and unnatural drainage patterns may concentrate runoff, resulting in increased bank erosion, which causes an additional loss of riparian vegetation and undercut banks, and eventually causes widening and downcutting of the stream channel. Streams that are channelized and/or diked frequently lack native riparian vegetation and provide little coho salmon habitat value.

In developed areas, point source and nonpoint source pollution are common. Sediments washed from urban and industrial areas often contain trace metals such as copper, cadmium, zinc, and lead (CSLC 1993, Sandahl et al. 2007). An acute example of this phenomenon is that toxic storm water runoff from urban and industrial sources is leading to high pre-spawn mortality of adult coho salmon in tributaries to Washington's Puget Sound (Booth et al. 2006). In addition, improperly maintained underground septic systems in residential areas can leach bacteria and nutrients into the water table. One significant emerging issue is the input of pharmaceuticals, endocrine disruptors, and personal care products, which are not effectively removed in standard treatment processes (Sumpter and Johnson 2005). These, together with pesticides, herbicides, fertilizers, gasoline, and other petroleum products, contaminate drainage waters and harm juvenile coho salmon and their aquatic invertebrate prey (Crisp et al. 1998, Flaherty and Dodson 2005). The North Coast Regional Water Quality Control Board (NCRWQCB 2001) reported that non-point-source pollution is the cause of 50 to 80 percent of impairment to water bodies in California.

Additionally, the magnitude of peak flow and pollution increases with increases in total impervious area (TIA; e.g., rooftops, streets, parking lots, sidewalks). Spence et al. (1996) recognized that channel damage from urbanization is clearly recognizable when TIA exceeds 10 percent, and that reduced fish abundance, fish habitat quality and macroinvertebrate diversity are seen with TIA levels from 7 to12 percent (Klein 1979, Shaver et al. 1995). May et al. (1997) showed almost a complete simplification of stream channels as TIA approached 30 percent and measured substantially increased levels of toxic storm water runoff in watersheds with greater than 40 percent TIA. Booth and Jackson (1997) found that total impervious area greater than 10 percent caused increased peak flows, decreased base flows, simplified channel conditions,

increased non-point-source storm water pollution, and resulted in a loss of aquatic system function.

Urban Growth Management

Urban growth management in both Oregon and California has some significant shortcomings that prevent the full protection of coho salmon habitat. Inside Oregon's urban growth boundaries, some upgraded riparian area protection was afforded under the Oregon Coastal Salmon Restoration Initiative (The Oregon Plan; State of Oregon 1997) and local governments amended their local comprehensive county general plans to implement these new requirements. Unfortunately, this goal only provides general guidance and does not require establishment and protection of riparian vegetation and wetlands. Buffer widths or types for riparian and wetlands are not included in these guidelines, leaving stream bank and riparian vegetation protection lacking, and continuing to allow for the degradation of coho salmon habitat. California urban growth management was not cited as a reason for listing SONCC coho salmon in 1997, however, the rapid population growth in California has caused harm to coho salmon and their habitat and may constitute a reason to evaluate urban growth management practices and their effectiveness at protecting SONCC coho salmon.

County and city planning in both Oregon and California (Mendocino, Humboldt, Siskiyou, Trinity, Del Norte, Lake, Curry, Josephine, Jackson, and Klamath counties) benefit from the development and implementation of comprehensive general plans that include some protective measures for fish and wildlife species and habitat. The Humboldt County General Plan helps to sustain and enhance water resources throughout Humboldt County, which is part of the SONCC coho salmon ESU. Through its policies and standards, it is an effective tool to ensure that new development occurs without damaging water resources on an individual and cumulative basis. The Plan also serves to guide the County in its interaction with neighboring counties, state, and federal agencies and lawmakers. It also directs the County's activities and commitment of resources. The plan includes a water resources element which addresses water planning issues including river and stream water quality, stormwater runoff, groundwater management, water needs of fish and wildlife, water consumption, conservation and re-use methods, and state and federal regulations. The goals of the water resources element include: High quality and abundant surface and groundwater water resources that satisfy the water quality objectives and beneficial uses , river and stream habitat capable of supporting abundant salmon and steelhead populations and sufficient water flows, support of salmon and steelhead recovery plans, recreation activities, and the economic needs of river dependent communities, and no additional upper or mid-level watershed exports from rivers flowing through the county. Siskiyou County also has a comprehensive General Plan that works towards protection of water quality, ecosystem processes and the natural environment.

3.2.7 High Intensity Fire

High intensity fires affect salmon and salmon habitat in a number of ways. Although over the long-term fire can have beneficial impacts on salmon habitat, over the short-term catastrophic fires are known to denude riparian areas, which in turn increase water temperatures through the loss of riparian shading (Dwire and Kauffman 2003, Minshall 2003, Spencer et al. 2003). Snow pack and water retention are also reduced in denuded areas affecting the hydrology of the basin

(Minshall 2003). Fire in upslope areas can also lead to increased soil erosion and sediment delivery, which in turn can result in stream aggradation, pool filling, and in extreme cases landsliding, debris torrents, or other forms of mass wasting (Elder et al. 2002). Many watersheds have experienced a change in their fire regime due to past land use, drought and climate change (Fried et al. 2004). Limited information suggests that the vulnerability of a population to fire stems from the quality of habitat, the amount and distribution of habitat, and habitat connectivity (Gresswell 1999, Dunham et al. 2003).

Fires pose the greatest threat to coho salmon in dry, inland areas where high intensity fire naturally occurs across large areas. Low intensity fires are considered beneficial to coho salmon habitat because they burn on the ground and remove many of the smaller trees and shrubs, while leaving the larger, more fire resistant trees (Minshall 2003). This type of fire prevents fuel loading and forest crowding while potentially boosting invertebrate production (Minshall 2003). Currently fire is listed as a high or very high threat in nine populations (Table 3-8).

Fire risks will continue to increase in the future due to climate change as conditions become drier and hotter in susceptible areas. Higher temperatures, reduced snowpack, and earlier spring snowmelt all contribute to the frequency, intensity, and extent of fires. The fire season has already begun to stretch longer into the spring and fall with an increase of 78 days over the last three decades across the western United States. Fire seasons will continue to increase and conditions will continue to favor large-scale, high intensity fires. Studies have shown that the probability of large fires (more than 500 acres) will increase by more than 75 percent in areas within the Klamath and Smith River basins with increases of 50 percent seen throughout inland areas of northern California and southern Oregon (Luers et al. 2007). Elevated fire frequency and intensity will continue to degrade stream conditions through sedimentation and loss of riparian vegetation.

3.2.8 Mining and Gravel Extraction

Currently, mining within the SONCC coho salmon ESU is primarily in the form of instream gravel mining, placer mining, suction dredging and upslope hardrock mining. The greatest threat from instream gravel mining is the alteration of channel morphology and hydraulic processes which alter the quantity and quality of instream habitat (e.g., pools and riffles) available (Kondolf 1997). The greatest threat from upslope mining is the increased potential for chemical, sediment or other types of contaminants to enter watercourses. Threats from placer mining and suction dredging include the rearrangement or destabilization of substrate and subsequent changes to macroinvertebrate assemblages (Kondolf and Wolman 1993). Mining and gravel extraction are listed as a high or very high threat in five populations.

Gravel extraction has the potential to impact channel form, sediment delivery, and hydrologic functions in a river or stream (Brown et al. 1998). The level of this threat is primarily dependent on the location in which it takes place, the intensity, and the types of methods used. Instream gravel mining affects habitat primarily through the skimming of gravel bars. Lowered bars result in unstable riffles that scour redds, wider and shallower channels that present migration barriers, and simplified habitat with fewer pools for juvenile rearing and adult holding (Kondolof and Swanson 1993).

Instream gravel mining is regulated at the federal, state, and county levels in California and Oregon. Federal regulations that apply in both states include permitting under Section 404 of the Clean Water Act (administered by the Army Corps of Engineers), the General mining Act of 1872, the Federal Land Policy and Management Act (FLPMA), ESA consultation regulations on the issuance of the federal permit to mine, and the Hardrock Mining and Reclamation Act.

Hydraulic mining (placer and suction dredging) can have a negative effect on habitat quality and lead to direct mortality through entrainment of eggs and offspring and the disturbance and alteration of streambed substrate (Griffith and Andrews 1981). Seasonal protections to minimize these effects have been effective by making the timing of permitted suction dredging when eggs and larvae will not be entrained. Material is often deposited into tailing piles, creating unnatural channel formations and flows. The persistence of such features is variable and the impacts can be seasonal and site-specific or long-term and widespread. Tailings piles are unstable and egg-to-fry survival was found to be reduced for Chinook salmon that spawn in tailings (Harvey and Lisle 1999), a finding that likely also applies to coho salmon. Lode or hard-rock mining in upland areas has the potential to unearth contaminants, which can eventually make their way into tributary and river systems.

Placer mining has the potential to alter riparian areas, damage instream habitat, and input fine sediment and pollutants. Past placer mining has damaged some riparian areas to the point where future recruitment of vegetation is impossible. Additional threats from placer mining include removal of riparian vegetation leading to long-term increases in water temperature and lack of wood recruitment, potential water diversions, potential streambank failures and increased sediment. When stream channels are changed or sediment concentrations are increased through placer mining, it can affect benthic invertebrates in the stream. Their populations can decline, or the species types may change and these changes can place stress on fish populations (Wagener and LaPerriere 1985). Results showed that placer mining caused increased turbidity and increased amounts of settleable solids and suspended sediments. These effects were correlated with decreased density and biomass of invertebrates (Wagener and LaPerriere 1985).

Federal Regulations

The Bureau of Land Management (BLM) has the primary responsibility for administering the laws and regulations regarding the disposal of all minerals from all federally owned lands. The BLM's statutory authority here is derived from the General Mining Law of 1872, as amended (30 U.S.C. §§ 22 et seq.), the original public land authority in 43 U.S.C. §§ 2, 15, 1201 and 1457, and FLPMA (43 U.S.C. 1701 et seq.). These statutes, together with the implementing regulations (43 CFR Parts 3710-3870) generally make up the body of the mining law system. Most Federal agencies have regulations to protect the surface resources of Federal lands during exploration and mining activities. In addition, CWA section 404 and Army Corps of Engineers (Corps) implementing regulations require a permit from the Corps for placement of material, impoundments, or other control of water in waters of the United States

California Regulations

In California, state regulations include the requirement to obtain a Streambed Alteration Agreement from CDFG, and the Surface Mining and Regulation Act (SMARA). SMARA is

implemented by each individual County through the issuance of Conditional Use Permits (including the recognition of vested rights that were in place prior to SMARA). For suction dredging, new regulations in California including special closed areas, closed seasons, and restrictions on methods and operations have been developed to minimize and prevent negative impacts from mining operations. These new regulations in place to help protect habitat, but careful monitoring of mining activity must occur to ensure that there is compliance.

In August 2009, all California instream suction dredge mining was suspended following enactment of state law SB 670 (Wiggins) which prohibits the use of vacuum or suction dredge equipment in any California river, stream or lake, regardless of whether the operator has an existing permit issued by DFG. The moratorium does not apply to suction dredging operations performed for the regular maintenance of energy or water supply management infrastructure, flood control, or navigational purposes. While DFG was in the process of completing a court-ordered environmental review of its permitting program, a new state law, AB 120, was enacted to extend the moratorium until June 30, 2016. Two other specifications of AB 120 are that any "new regulations fully mitigate all identified significant environmental impacts." and that the suction dredge permit fees be increased to fully fund all of DFG's costs for administrating the suction dredge program.

Oregon Regulations

The State of Oregon has a number of mining regulations. Many state prohibitions exist, and most public lands are off limit to exploration or development of mining claims. The Oregon Department of Environmental Quality requires a permit to be issued before mining can begin. Operating an in-stream suction dredge and discharging the resultant wastewater into the water requires a NPDES General Permit 700-J. Persons assigned to the NPDES 700-PM permit must not operate a suction dredge more than 16 horsepower or with an inside diameter intake nozzle greater than four inches in essential salmon habitat (ESH). Suction dredging is allowed only during the in-water work schedule (Timing of In-Water Work to Protect Fish and Wildlife Resources) as set by ODFW, and measures must be taken to prevent the spread of invasive species. Suction dredging is prohibited on any stream segment that is listed as water quality limited for sediment, turbidity, or toxics on the list published by DEQ.

Mining must not cause any measureable increase in turbidity in selected wilderness and reserve areas. Measureable increase in turbidity is measured as visible turbidity. Performing small-scale, non-chemical off-stream placer mining adjacent to a waterway requires a Water Pollution Control Facility (WPCF) General Permit 600, which prohibits discharge of wastewater generated by the operation to the waters of the state. These permit requirements were set in place to protect and preserve fish and wildlife species inhabiting the waterways of the state of Oregon (Oregon Division of State Lands 1999).

Oregon state law also restricts equipment size, nozzle diameter, and suction speed and efficiency. In the SONCC coho salmon ESU, as of June 1998, portions of the Rogue, Illinois, and Elk rivers, as well as areas of the North Fork of the Smith River are closed to mineral entry except for federal mining claim holders working within valid claims under approved Plans of Operations. While these prohibitions and requirements help curtail mining activities, illegal mining has been recently documented in the SONCC coho salmon ESU (e.g., Preusch 2009, Learn 2011).

3.2.9 Dams and Diversions

Besides often acting as fish passage barriers (with impacts discussed below), dams and diversions lead to altered hydrologic function and can lead to water quality issues (Raymond 1979, Levin and Tolimieri 2001). As human population growth continues, the number of water diversions increase and threaten SONCC coho salmon populations. Currently, dams and diversions are a high or very high threat in 16 populations. Permanent dams are almost always associated with water control features for flood control, municipal or agricultural water uses, and/or hydropower operations. Temporary dams are usually built for recreational or agricultural purposes on private land. Many dams are associated with water diversions. Dams and diversions alter the hydrologic regime and shift the timing and magnitude of flow events (such as the spring freshet) (Levin and Tolimieri 2001). These changes can lead to reduced survival and production of coho salmon.

Reduced stream flows from dams and water diversions in the summer and fall months cause fragmented habitats and increased stream temperatures while impeding the geomorphological processes that maintain stream health (Ligon et al. 1995). In some areas, seasonal and permanent dams are installed to provide water for agricultural operations and lead to altered stream function, migration barriers, changes in stream temperature, and temporary increases in sedimentation (Ligon et al. 1995). Both juveniles and adults use flow events as migrational cues and depend on natural flow regimes for migration and access to habitat. Water quality can also be impaired by low flow through lack of flushing, water stagnation, and concentration of pollutants and nutrients.

Recent dam removal projects throughout the ESU have allowed for improved passage in the Rogue River, and efforts towards installing fish screens have led to significantly decreased impacts to salmonids. Many diversions in the Shasta basin now have CDFG and NMFS approved fish screens installed, and Scott Valley has 100 percent of the diversions located in coho habitat screened to prevent impacts to SONCC coho salmon.

Recent efforts in the Klamath Basin have brought about the creation of the Klamath Basin Hydroelectric Settlement Agreement and the Klamath Basin Restoration Agreement. The Klamath Hydroelectric Settlement Agreement, or KHSA, lays out the process for conducting necessary additional studies, environmental reviews, and a decision by the Secretary of Interior (Secretarial Determination) as to whether removal of the lower four dams on the Klamath River owned by PacifiCorp 1) will advance restoration of the salmonid fisheries of the Klamath Basin, and 2) is in the public interest, which includes but is not limited to consideration of potential impacts of on affected local communities and Tribes. The KHSA includes provisions for the interim operation of the dams prior to dam removal as well as the process to transfer, decommission, and remove the dams if the Secretarial Determination is affirmative. The KHSA establishes 2020 as the target date for dam removal. This timeline allows for completion of necessary environmental and regulatory reviews and the collection of $200 million for dam removal from PacifiCorp customers if the Secretarial Determination is affirmative.

The Klamath Basin Restoration Agreement, or KBRA, is a settlement agreement among many diverse parties that creates a solid path forward on long-standing, resource disputes in the Klamath Basin. The KBRA takes a multi-dimensional approach that resolves complex problems

by focusing on species recovery while recognizing the interdependence of environmental and economic problems in the Basin's rural communities. The goals of the KBRA are to 1) restore and sustain natural production and provide for full participation in harvest opportunities of fish species throughout the Klamath Basin; 2) establish reliable water and power supplies which sustain agricultural uses and communities and National Wildlife Refuges; and 3) contribute to the public welfare and the sustainability of all Klamath Basin communities. The key negotiated outcomes of the KBRA include mutually-beneficial agreements for the Klamath, Karuk, and Yurok Tribes not to exercise water right claims that would conflict with water deliveries to Reclamation's Klamath Project water users and for project water users to accept reduced water deliveries. As a result, there would be more support for fisheries restoration programs, greater certainty about water deliveries at the beginning of each growing season, and agreement and assurances that certain of the parties will work collaboratively to resolve outstanding water-right contests pending in the Oregon Klamath Basin Adjudication process. In addition, the KBRA includes an Off-Project voluntary Water Use Retirement Program in the Upper Basin, three restoration projects intended to increase the amount of water storage in the Upper Klamath Basin, regulatory assurances, county and tribal economic development programs, and tribal resource management programs. Copies of the KHSA and KBRA in their entirety are available electronically at: http://klamathrestoration.gov/. The implementation of these two agreements will be a significant step forward in restoring fish populations in the Klamath River Basin, once a stronghold for SONCC coho salmon.

Acts

Federal statutes that include provisions relevant to instream flow protection include the ESA, CWA, National Environmental Policy Act (NEPA), and the Federal Power Act.

Water Allocation

Given the lack of federal regulatory authority over instream flow in many areas and waterbodies, state water laws are the primary mechanism for protecting instream flow in many areas. In the area of the SONCC coho salmon ESU, the states of Oregon and California are charged with allocating and adjudicating water quantities to qualified users, as well as enforcing water rights. Oregon's water rights system is based primarily on the doctrine of prior appropriation, although some form of riparian water rights still exist (Oregon Water Resources Department (OWRD) 2009) and instream flow rights can be established through water right purchase or lease. Surface and groundwater use in Oregon is administered by the Water Resources Department (OWRD), which is responsible for implementing Oregon's water policy.

Oregon was one of the first western states to recognize instream flow as a beneficial use. In 1955 the state adopted minimum stream flows to support aquatic life through administrative rules, and in 1983 amendments were adopted that authorized ODFW, ODEQ, and the Oregon Department of Parks and Recreation to apply for minimum instream flow rights. Then, in 1987 and 1993, further amendments strengthened instream flow rights, allowing for transfers and for the use of water markets to acquire instream flow rights (OWRD 2009).

State resource managers in Oregon have also attempted to protect and conserve instream flows, and promote water conservation, through the implementation of voluntary programs for private

water users. The allocation of conserved water program, administered by OWRD, allows a water user who conserves water to use a portion of the conserved water on additional lands, lease or sell the water, or dedicate the water to instream use. The program is intended to promote the efficient use of water to satisfy current and future needs, both out of stream and instream. Oregon's instream leasing program is also designed to provide a voluntary means to aid the restoration and protection of streamflow. This arrangement provides water users with options that protect their water rights while leasing water for instream benefits. The success of this program is largely dependent on the participation of landowners and therefore the program may be unable to meet the instream flow needs of coho salmon populations in some areas.

Responsibility for water allocation and use enforcement in California is shared among several agencies. California courts have jurisdiction over the use of percolating ground water, riparian use of surface waters, and the appropriate use of surface waters initiated prior to 1914 (California Department of Water Resources (CDWR) 2001). The State Water Resources Control Board (SWRCB) is responsible for the water rights and water quality functions of the state (CDWR 2001). The SWRCB has the jurisdiction to issue permits and licenses for appropriation of water from surface and underground streams. This board also has the authority to declare watercourses fully appropriated. Many of the streams and rivers in the California portion of the ESU have been deemed to be fully appropriated by the SWRCB (Table 3-9). A declaration that a stream system is fully appropriated means that the supply of water in the stream system is being fully applied to beneficial uses, and the SWRCB has determined that no water remains available for appropriation. From and after the date of adoption of a declaration that a stream system is fully appropriated, and subject to subdivision the board shall not accept for filing any application for a permit to appropriate water from the stream system and the board may cancel any application pending on that date.

Table 3-9. Declaration of fully appropriated stream systems according to the California State Water Resources Control Boards.

County	Stream	Tributary to	Critical Reach
Del Norte County			
	Smith River	Pacific Ocean	refer to Section 5093.54 of California Wild and Scenic Rivers Act for specific critical reaches
	Jordan Creek	Lake Earl	from the confluence with Lack Earl upstream
Humboldt County			
	Eel River	Pacific Ocean	The main stem from 100 yards below Van Arsdale Dam to the Pacific Ocean
	Klamath River	Pacific Ocean	from the main stem about 100 yards below Iron Gate Dam to the Pacific Ocean
	South Fork Eel River	Eel River	the south fork of the Eel from the mouth of Section Four Creek near Branscomb to the river mouth below Weott
	South Fork Trinity River	Trinity River	from the junction of the river with State Highway Route 36 t the river mouth near Salyer
	Trinity River	Klamath River	the main stem from 100 yards below Lewiston Dam to the river mouth at Weitchpec
	Van Duzen River	Eel River	from Dinsmore Bridge downstream to the river mouth near Fortuna
	Jacoby Creek	Humboldt/Arcata Bay	from the confluence of Jacoby Creek and Humboldt/Arcata Bay upstream
	Mad River	Pacific Ocean	from the mouth of the Mad River at the Pacific Ocean upstream
Mendocino County			
	Brush Creek	Pacific Ocean	from the mouth at the Pacific Ocean upstream
	Middle Fork Eel River	Eel River	from the intersection of the river with the southern boundary of the Middle Eel-Yolla Bolly Wilderness Area to the river mouth at Dos Rios
	North Fork Eel River	Eel River	from the Old Gilman Ranch downstream to the river mouth near Ramsey
	Mill Creek	Middle Fork Eel River	from the SE corner of Section 16, T22N, R12W, MDB&M where the accretion flow comes into Mill Creek upstream

County	Stream	Tributary to	Critical Reach
Siskiyou County			
	North Fork Salmon River	Salmon River	from the intersection of the river with the south boundary of the Marble Mountain Wilderness Area to the River mouth
	Scott River	Klamath River	from the mouth of Shackleford Creek west of Fort Jones to the river mouth near Hamburg
	Wooley Creek	Salmon River	from the western boundary of the Marble Mountain Wilderness Area to its confluence with the Salmon River
	French Creek	Scott River	from the confluence of French Creek and the Scott River upstream
	Scott River	Klamath River	at the U.S. Geological Survey located on the Scott River near Fort Jones upstream
	Shackleford Creek	Scott River	from the confluence of Shackleford Creek and the Scott River upstream
	Willow Creek	Klamath River	from the York Bridge Road located within Section 8, T46N, R5W, MDB&M, upstream
	Seiad Creek	Klamath River	From the confluence of Seiad Creek and the Klamath River upstream
	Shasta River	Klamath River	from the confluence of the Shasta River and the Klamath River upstream
	Shasta River	Klamath River	from the confluence of Willow Creek located within Section23, T44N, R6W, MDB&M upstream
	McKinney Creek	Klamath River	about 1 1/2 miles downstream from the point of diversion on McKinney Creek upstream
	East Fork of SF of the Salmon River	Salmon River	at a point on the East Fork of South Fork Salmon River located within T39N, R10W, (Shadow Creek Campground(upstream
	Douglas Creek	Klamath River	from a point on Douglas Creek located within the NE1/4, Section 19, T15N, R7E, MBD&M upstream
Trinity County			
	New River	Trinity River	from the intersection of the river with the southern boundary of the Salmon-Trinity Primitive Area downstream to the river mouth near Burnt Ranch
	North fork Trinity River	Trinity River	from the intersection of the river with the southern boundary of the Salmon-Trinity Primitive Area downstream to the river mouth at Helena
	Mule Creek	Trinity River	from Clair Engle Lake upstream

The CDWR is responsible for planning the use of state water supplies, and consults with the California Water Commission to develop rules and regulations for this purpose (CDWR 2001). The vast majority of California's groundwater is unregulated and the state does not have a comprehensive groundwater permit process to regulate ground water withdrawal. The lack of

groundwater regulation has led to overutilization of this resource, which has had major impacts on surface flow and constitutes a major shortcoming of California water law.

In 1991, California adopted changes to its water laws that permitted the transfer of existing consumptive water rights to the purpose of instream flow through either purchase or lease. State law does not permit new appropriations of water for instream flow. When a new water use permit application is submitted, the State Water Board must notify CDFG, which has the authority to recommend amounts of water necessary to preserve fish, wildlife, and recreation in the affected stream. The board then considers these recommendations and may set instream flow requirements as conditions for the new permit. In this way, current flows can be protected even though new appropriations for instream flow rights are prohibited (California Environmental Protection Agency 2011).

More recent efforts to protect instream flows include the adoption of California Water Code section 1259.4, and the adoption and use of Section 1707. California Water Code section 1259.4 addresses the 2002 draft guidelines that CDFG and NMFS presented to the SWRCB for maintaining instream flows downstream of water diversions in mid-California coastal streams. The draft joint guidelines call for limiting new water diversions to only the winter period from December 15 to March 31, establishing bypass flows for new dams, establishing a cumulative maximum rate of withdrawal, and restricting construction of new on-stream dams. Water transfers for dedicated instream uses are accomplished through Section 1707. An instream flow dedication under Section 1707 allows a water user to transfer all or a portion of any water right to instream uses – for example, designating that such conserved water must remain in the watercourse for the benefit of aquatic habitat. It is available to owners of either riparian or appropriative water rights, and can be crafted for either short-term (less than a year) or long-term duration. These transfers may be used to ensure that water flows downstream to satisfy any applicable federal, state, or local regulatory requirements governing water quantity, water quality, instream flows, fish and wildlife, wetlands, recreation, and other instream beneficial uses. Additionally, in November of 2009, the California State Legislature passed a series of bills that encourage stricter groundwater monitoring and enforcement of illegal diversions, more ambitious water conservation policy, and water recycling and conservation programs. If effectively implemented, these California water bills should contribute to improved instream habitat in the future.

Instream Flow Requirements

Many rivers within the SONCC coho salmon ESU contain large dams. Dam operators at most of these dams have regulatory mandates to maintain adequate instream flows for the protection of fish and wildlife species. Examples of dams with flow requirements include J.C. Boyle, Copco 1, Copco 2, and Iron Gate dams on the Klamath River; Trinity and Lewiston dams on the Trinity River; R.W. Matthews Dam (Ruth Lake) on the Mad River, and Scott Dam (Lake Pillsbury) in the Eel River. Large dams lacking instream flow requirements include William L. Jess Dam (Lost Creek Reservoir) on the Rogue River, Applegate Dam on the Applegate River, and Dwinnell Dam on the Shasta River.

On the Trinity River, the Bureau of Reclamation is required to release between 369,000 and 815,000 acre feet to the Trinity River annually depending on the water year type. Discharge from

Lewiston Dam remains at 450 cfs during the summer months, 300 cfs during the winter months, and has a variable flow regime in the spring depending on the water year type.

The total volume of water impounded and diverted by the Humboldt Bay Municipal Water District (HBMWD) represents a small percentage of the natural yield of the Mad River watershed. The Mad River's average annual discharge into the Pacific Ocean is just over 1,000,000 acre-feet (available at http://www.hbmwd.com/water_supply). Ruth Lake, in its entirety, represents less than 5 percent of the total average annual runoff from the Mad River basin. The entire 48,030 AF capacity of Ruth Lake is not drawn down each year, so the amount of winter-season runoff captured in the reservoir is yet a smaller percentage of the total runoff. With respect to diversions, the current withdrawal rate at Essex is approximately 25 to 30 MGD (28,000 to 34,000 acre-feet per year), which is only 3 percent of the total annual average runoff of the Mad River watershed (available at http://www.hbmwd.com/water_supply). The full diversion capacity of 75 MGD (84,000 acre-feet per year) is just 8 percent of the total annual average runoff of the watershed.

The Potter Valley Project diverts the majority of upper mainstem Eel River flows out of the basin. From 1992 to 2004, up to approximately 160,000 AF of Eel River water were annually diverted into the East Fork of the Russian River for hydropower production and agricultural uses. Until 2004, flows released downstream of Cape Horn Dam were approximately 3 cubic feet per second (cfs) during most of the summer. In 2004, the Federal Energy Regulatory Commission issued an order requiring Pacific Gas and Electric (PG&E) to implement an instream flow regime consistent with the Reasonable and Prudent Alternative in the NMFS 2002 Biological Opinion. The new flow requirement increased the minimum Cape Horn Dam release flows and incorporated within-year and between-year variability. Minimum flows are dependent on a number of factors and formulas, including cumulative inflow into Lake Pillsbury, current and previous water year, and time periods.

3.2.10 Invasive/Non Native Alien Species

Invasive or non-native alien species pose a threat to several populations in the SONCC coho salmon ESU (Table 3-8). Sacramento pikeminnow are prevalent throughout much of the Eel River basin and have recently been discovered in Martin Slough, a tributary to Elk River in Humboldt Bay and brown trout have been observed in the Upper and Lower Trinity River (CDFG 1997, Waters 1983, Dewald and Wilzbach 1992, Wang and White 1994, McHugh and Budy 2006). Both species reduce native coho salmon populations by increasing competition for food resources, increasing predation on juveniles, and utilizing less than desirable water quality conditions to flourish and become more abundant, and out-competing native salmonids. Additionally, recent reports have shown that the New Zealand Mud Snail has been observed in Redwood Creek (Benson 2010), although little if any information exists on the effects that these animals have on local salmonids.

Reed canary grass is an invasive non-native perennial grass that was not identified as a threat at the time of SONCC coho salmon federal listing. The grass has been identified to prohibit native riparian growth, choke stream channels, provide poor to non-existent habitat for fish and other native aquatic wildlife, inhibit the mobility of fish at lower flows, increase sedimentation, contribute to low levels of dissolved oxygen, and cause overbank flooding during winter and

spring base flow conditions (Miller et al. 2008). In addition, over 150 adult unspawned coho salmon were found dead in a field dominated by reed canary grass, likely stranded by the dense reed canary grass when high flows receded quickly in an ill-defined channel (Carrasco 2000). Although that mortality event occurred outside of the SONCC coho salmon range, the invasive grass is found throughout southern Oregon and northern California and is a threat to SONCC coho salmon and their habitat. Overall, the threat of reed canary grass has increased since the last status review.

Some basins in the SONCC coho salmon ESU, including Hunter, Strawberry, and Norton/Widow White creeks, have extensive residential development in their lower floodplains and riparian areas. In these areas, it is likely that invasive plant species will spread from residential landscaping into riparian areas, particularly if there are pre-existing gaps in the riparian vegetation. Some of these species could impede restoration of riparian forests and wetlands. The extent to which this has already occurred is unknown.

3.2.11 Hatcheries

Hatcheries are believed to pose a significant threat to populations where they occur in the SONCC coho salmon ESU. As discussed in section 3.1.1, hatcheries and the introduction of hatchery fish into wild populations can have direct and indirect effects on wild, native fish populations. More information regarding hatcheries can be found under the adverse hatchery related effects in the above mentioned stress (limiting factor) section.

3.2.12 Fishing and Collecting

Fisheries Harvest Management

Significant changes in harvest management have occurred since the late 1980s, resulting in substantial reductions, and in most cases, cessation in harvest of SONCC coho salmon. Historically, ocean harvest of SONCC coho salmon has occurred in coho- and Chinook-directed commercial and recreational fisheries off the coasts of California and Oregon and SONCC-origin coho salmon have been shown to experience incidental morality due to hooking and handling in other fisheries, especially the Chinook salmon fishery north of Humbug Mountain (PFMC 1999, 2000, 2001, 2002, 2003).

Originally enacted in 1976, the Magnuson-Stevens Fishery Conservation and Management Act (MSA) established the conservation and management of marine fisheries in the U.S, and created eight regional fishery management councils, of which the Pacific Fisheries Management Council (PFMC) oversees the fisheries along the western states. Because of the decline of coho salmon, the PFMC closed the commercial and recreational fisheries for coho salmon in 1994 and 1995, respectively. Because coho-directed fisheries and coho salmon retention have been prohibited off the coast of California since 1996, the SONCC coho ocean exploitation rate is very low and attributable to non-retention impacts (bycatch) in California and Oregon Chinook salmon directed fisheries and in Oregon's mark-selective directed coho salmon fisheries.

When amended in 1996, the MSA established essential fish habitat protection and reduced bycatch limits. The MSA requires NMFS to provide conservation recommendations to conserve essential fish habitat. In response, federal action agencies are then required to respond to

NMFS's conservation recommendations and indicate that the recommendations will be implemented or to provide alternatives to the recommendations that would avoid, mitigate, or offset the impact of the activity on the habitat. Additionally, the PFMC is working to reduce bycatch impacts by setting the bycatch limit of coho salmon to 13 percent in the Chinook salmon ocean fisheries. In 1999, NMFS issued a biological opinion requiring that the overall annual ocean exploitation rate for Rogue and Klamath rivers (R/K) hatchery coho salmon remain less than 13 percent (NMFS 1999). In 2001, the PFMC adopted management measures for Federal ocean waters under which all key coho salmon management objectives, based on the 1999 NMFS biological opinion, the Pacific Coast Salmon Plan, and the OCN Coho Salmon Work Group recommendations, were met. Current regulations include time and area closures, seasonal quotas, minimum sizes, gear restrictions, and allowable take.

In establishing fishing seasons and regulations each year, the Pacific Fishery Management Council (PFMC) considers the potential impacts on various ESA-listed stocks within the region. Because there are no data on exploitation rates on wild SONCC coho salmon, Klamath and Rogue River (KR) hatchery stocks have traditionally been used as a fishery surrogate stock for estimating exploitation rates on SONCC coho. Current coho salmon exploitation rates based on the Rogue/Klamath time series (2000 to 2010) show a decrease from 6 percent on average from 2000 to 2007, to between 1 and 3 percent in 2008 and 2009. This decrease is believed to be due to the closure of nearly all salmon fisheries south of Cape Falcon, Oregon. Recreational fishing was resumed in 2010. California's statewide prohibition of coho salmon retention keeps the impacts from freshwater recreational fisheries on SONCC coho salmon low, including allowance for sporadic mark-selective coho salmon retention in the Oregon part of the ESU. The available information indicates that the level of SONCC coho salmon fishery impacts have not significantly changed since the 2005 salmon and steelhead status review update (Good et al. 2005), except for small decreases in 2008 and 2009.

3.2.13 Inadequate Regulatory Mechanisms

Inadequate regulatory mechanisms were identified as a factor for listing when SONCC coho salmon were listed in 1997, and the problems associated with these regulations continues to hinder salmon recovery to this day. The set of regulatory mechanisms which will govern this future recovery span a full range of protective strengths and weaknesses and provide a varying degree of protection for populations in the SONCC coho salmon ESU. Since 1997, many regulatory mechanisms that were originally cited as being inadequate have been strengthened in their ability to protect coho salmon and their habitat. In addition, many new management plans and programs have been implemented which either directly or indirectly benefit coho salmon. However, because of the lack of coordination in implementation and management, some regulations are not fully implemented or monitored for compliance and therefore do not provide adequate, or even minimal protection. In addition, there is an overall lack of regulations to fully address the range and magnitude of current and future threats to recovery. As discussed below, the regulatory landscape in which recovery will take place has both strengths and weaknesses in terms of its ability to protect and restore SONCC coho salmon and habitat.

Although some of the current land and resource management policies in place are specifically designed to protect coho salmon and their habitat (e.g., Federal and State Endangered Species Acts), many are designed for other purposes and only indirectly protect SONCC coho salmon

populations (e.g., state forest practice rules). To achieve recovery, federal and state land managers will need to work together to provide comprehensive upland and instream habitat protection across the landscape and work together to implement a more cohesive set of land and resource management policies and plans. Several federal and state land management regulations and acts have been enacted to protect and preserve public lands for current and future public use, and to ensure that these lands are held in good condition, and species utilizing these lands are protected to ensure continued survival. Additionally, many federal and state regulations and acts aid in the protection of private lands and also work towards the protection of salmonids and other species not protected under state and federal laws for public lands. These regulatory mechanisms are in place to control and regulate mining activities, timber harvesting, instream dredging and construction, and urban growth. Many aspects of these regulations are regulated and monitored by both Federal and State agencies, and may apply to both public and private lands in both Oregon and California. Several inadequate regulatory mechanisms identified in the final rule listing the SONCC Coho Salmon ESU (62 FR 24588, 24596-24598; May 6, 1997) are discussed elsewhere in this chapter: Northwest Forest Plan (Section 3.2.5), State Forest Practices (Section 3.2.5), Water Quality Programs (Section 3.1.2), State Agricultural Practices (Section 3.2.4), Harvest Management (Section 3.2.12), and Hatchery Management (Section 3.2.11).

Dredge, Fill, and In-water Construction Programs

The Army Corps of Engineers (ACOE) regulates removal/fill activities under section 404 of the Clean Water Act (CWA) (see http://www.epa.gov/OWOW/wetlands/laws/). When listing the SONCC coho salmon ESU, NMFS noted that ACOE did not a methodology to adequately assess the cumulative effects in issuing permits for removal/fill activities under CWA section 404 (62 FR 24588, 24596; May 6, 1997). Although currently the ACOE requires an evaluation of cumulative impacts from these permits, the effectiveness of such evaluations at preventing cumulative impacts is unknown. Similarly, the section 401 water quality certification program, which is regulated by the states of California and Oregon, applies only to activities that require a federal permit or license (i.e., 404 permit or FERC license, respectively). Because the 401 certification requirements depend on the initiation of the 404 permitting or FERC licensing process, the 401 program also does not address exclusively upland activities. Therefore, the lack of review and jurisdiction for upland activities limits the ability of the 404 and 401 regulatory programs to provide adequate protection for coho salmon and its habitat. Other state and federal agencies are tasked with monitoring and addressing upland activities, but little oversight and manpower are put to these regulatory programs and processes. While the availability of regulatory agencies is useful in protecting salmon and their habitat, more could be done to provide greater protections in more areas to increase the authority and strength of these regulations.

California Endangered Species Act

In 2005, the state of California listed coho salmon between Punta Gorda and the Oregon border as threatened. The California listing protects coho salmon from direct take, and helps to ensure that projects or activities that have incidental adverse effects to coho salmon are reviewed and take is mitigated. In connection with the California state listing, a coho salmon recovery strategy was formally approved and adopted by the California Fish and Game Commission on February 4, 2004 (CDFG 2004). The recovery strategy includes over 700 conservation recommendations

covering a wide variety of land use activities, and over 200 more related to agricultural practices within the Scott and Shasta rivers, tributaries to Klamath River. To facilitate implementation, the CDFG has integrated the recovery strategy with the Fisheries Restoration Grant Program (FRGP) by increasing the likelihood that high priority actions receive funding. Currently the recovery plan is being implemented throughout the California portion of the ESU and a 5-year progress report is being developed. Limited funding and staff have impacted the state's ability to fully implement the plan in recent years. The state of Oregon has not listed coho salmon in southern Oregon.

Federal Endangered Species Act Protections

The major provisions of the Endangered Species Act of 1973, as amended,16 U.S.C. § 1531 et seq., set forth eligibility and procedural requirements for listing species as endangered or threatened, provides protections for those listed species, prohibits federal agencies from engaging in actions that jeopardize listed species or result in the destruction or adverse modification of their designated critical habitat without special exemption (section 7(h)(1)), and creates a framework for cooperation with states to conserve listed species and their habitat. The most direct mechanism for protection under the ESA is the section 9 take prohibition. Section 7(a)(1) makes it clear that Federal agencies must utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of endangered species and threatened species. Although Federal agencies have an affirmative obligation to conserve, an agency's 7(a)(1) actions are discretionary and priorities are often obligated to other management objectives.

Section 7(a)(2) states, in part, "[e]ach Federal agency shall, in consultation with and with the assistance of the Secretary [of Interior or Commerce, as appropriate], insure that any action authorized, funded, or carried out by such agency…is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of critical habitat of such species...unless such agency has been granted an exemption for such action…by the Committee pursuant to subsection (h) of this section." Since the time of listing, NMFS has conducted over 1,000 consultations on the effects of Federal actions on SONCC coho salmon and their critical habitat, including major projects on the Rogue, Trinity, Klamath, and Eel rivers. Interagency consultation, including technical assistance and section 7 consultations (both informal and formal) have often reduced or eliminated adverse effects to SONCC coho salmon, their designated critical habitat, or both.

Section 10(a)(1)(B) of the ESA allows NMFS to issue permits to non-Federal parties for incidental take of listed species, as long as, among other requirements, the impacts of the taking are minimized and mitigated to the maximal extent practicable and the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild. Neither section 7(a)(2) consultations nor section 10 permits are intended to require Federal agencies or permit holders to contribute to the recovery of listed species. However, in section 7(a)(2) consultations and in issuance of section 10(a)(1)(B) permits, the action or taking must not appreciably reduce the likelihood of survival and recovery of the listed species in the wild. Further, in biological opinions, NMFS frequently provides discretionary conservation recommendations, which, if implemented, would assist the action agency in meeting its section 7(a)(1) responsibilities.

Whenever a species is listed as threatened under the federal ESA, section 4(d) authorizes the Secretary to issue regulations as he deems necessary and advisable to provide for the conservation of such species, including taking prohibition or limitation of identified activities. Currently, the 4(d) rule for SONCC coho salmon (50 CFR § 223.203) does not necessarily streamline the regulatory process for review of activities that may benefit coho salmon, because NMFS has less experience reviewing activities under the 4(d) rule compared to experience in consultations under section 7(a)(2) or permits under section 10(a)(1)(B), and NMFS' approval of activities under the 4(d) rule requires an internal consultation under ESA section 7(a)(2)(d) review is less well established than section 7 or 10 programs and the current 4(d) rule also requires an internal section 7 consultation.

3.2.14 Ocean Conditions

Survival rates in the marine environment are strong determinants of population abundance for Pacific salmon (NMFS 2003). Poor ocean conditions have played a prominent role in the decline of coho salmon in California and Oregon and will greatly influence the ability to recover SONCC coho salmon. In general, coho salmon marine survival is about 10 percent (Bradford 1995), although there is a wide range in survival rates (from less than one percent to about 21 percent) depending upon population location and ocean conditions (Beamish et al. 2000, Quinn 2005). Marine survival and successful return as adults to spawn in natal streams is considered to be critically dependent on an individual's first few months at sea (Peterman 1982, Unwin 1997, Ryding and Skalski 1999, Koslow et al. 2002). In a detailed study of Puget Sound hatchery coho salmon, Mathews and Buckley (1976) estimated that 13 percent survived the first six months at sea, survival dropped to 9 percent after twelve months, and increased to 99 percent during the second year at sea.

Changes in the marine environment over the past decade demonstrate the impacts that changing ocean conditions can have on coho salmon populations (Beamish et al. 2000, Logerwell et al. 2003). For at least two decades, beginning about 1977, marine productivity conditions were unfavorable for the majority of salmon populations in the Pacific Northwest. Recent data from across the range of coho salmon on the coast of California and Oregon reveal there was a 72 percent decline in returning adults in 2007/08 compared to the same cohort in 2004/05 (MacFarlane et al. 2008). The Wells Ocean Productivity Index, a measure of Central California ocean productivity, revealed poor conditions during the spring and summer of 2006, when juvenile coho salmon from the 2004/05 cohort entered the ocean (McFarlane et al. 2008). Poor ocean productivity can be especially detrimental to coho salmon along the Oregon and California coast, because these regions lack extensive bays, straits, and estuaries, which could buffer adverse oceanographic effects (Bottom et al. 1986). Strong ocean upwelling in the spring of 2007 may have resulted in better ocean conditions for the 2007 coho salmon cohort (NMFS 2008a).

3.2.15 Stochastic Pressure from Small Population Size

A recent evolution in the field of conservation biology is the hypothesis that random events in small populations may have a large impact on population dynamics and population persistence. The peril that small populations face may be either deterministic (the result of systematic forces that cause population decline such as overexploitation, development, deforestation, loss of

pollinators, inability to find mates, or inability to defend against predators) or stochastic (the result of random fluctuations that have no systematic direction). These forces have been shown to reduce population size and when populations are reduced to very low densities, they can experience reduced rates of survival and reproduction (Allee 1938, Wood 1987). Over the long term, a series of unlucky generations in which there are successive declines in population size can lead to extinction even if the population is growing, on average.

Several populations in the SONCC coho salmon ESU have declined in numbers to such a low point that they are being influenced by natural stochastic processes that may make recovery of the ESU more difficult than currently thought (CDFG 2004). As natural populations get smaller, the number of interacting stochastic processes which influence the population increases. These stochastic processes can create alterations in genetics, breeding structure, and population dynamics that may interfere with recovery efforts and need to be considered when evaluating how populations within the ESU are going to respond to recovery actions. This stochastic pressure can express itself in three ways: genetic, demographic and environmental.

Genetic stochasticity refers to changes in the genetic composition of a population unrelated to systematic forces (selection, inbreeding, or migration), i.e., genetic drift. Genetic stochasticity can have a large impact on the genetic structure of populations, both by reducing diversity within populations and by increasing the chance that deleterious recessive alleles are expressed. When populations are at levels below depensation, stochasticity can make both population viability and survival difficult to predict, due to the random variables that are now acting on the population. These processes, when working together, can cause reduced genetic diversity in a population (or populations), further decreases in population size, or shifts in life history traits. Reduced diversity could limit a population's ability to respond adaptively to future environmental changes. In addition, the increased frequency with which deleterious recessive alleles are expressed (because of increased homozygosity) could reduce the viability and reproductive capacity of individuals.

Demographic stochasticity refers to the variability in population growth rates arising from random differences among individuals in survival and reproduction within a season. This variability will occur even if all individuals have the same expected ability to survive and reproduce and if the expected rates of survival and reproduction don't change from one generation to the next. Even though it will occur in all populations, it is generally important only in populations that are already fairly small. Environmental stochasticity is the type of variability in population growth rates that refers to variation in birth and death rates from one season to the next in response to weather, disease, competition, predation, ocean conditions, or other factors external to the population.

In these small populations, recovery from low densities may be significantly delayed or not occur at all and be displayed through a decrease in per-capita growth rate. This reduced per-capita growth rate at low densities is also known as depensation (Liermann and Hilborn 2001). Many mechanisms can lead to depensation and are usually displayed through changes in the following mechanisms: reduced probability of fertilization, impaired group dynamics, conditioning of the environment and predator saturation (Liermann and Hilborn 2001). A population’s dynamics are depensatory if the growth rate decreases along with density or abundance decreasing to low levels. Components of the life history, such as fecundity or

survival, or the mechanisms that affect these components are called depensatory if they decrease the growth rate along with density or abundance. At extremes, these depensatory dynamics have negative per-capita growth rates at low densities and are called critical depensation (Clark 1985). The critical density at which the per-capita growth rate becomes negative is of particular interest since populations reduced below this density face further decline and possibly extinction (Liermann and Hilborn 2001) and therefore being able to recognize when populations are entering or are in a depensatory state is vitally important in the efforts leading to recovering a species. However, recognizing when depensation is occurring has proven to be difficult, but current research utilizing parametric statistical analyses is beginning to be used to help better understand the population dynamics occurring in these small populations, similar to the SONCC coho salmon ESU.

These stochastic processes are likely influencing populations throughout the SONCC ESU. These processes and pressures need to be taken into account when prioritizing watersheds and associated recovery actions to ensure that efforts made to recover extremely small populations are successful, and that other processes are not hindering or defeating recovery efforts. These processes, while not serious when acting alone, can become significant contributors to population instability and decline when acting synergistically with other threatening processes. It may be difficult to know when a population is at a point that additional stochastic factors are playing a role in its recovery and viability, and so including, where possible, statistical population models to determine current pressures and threats is needed. Models like the Population Viability Analysis (PVA) have been shown to be extremely useful in obtaining a better understanding of the processes and pressures that are affecting small populations like those seen in the SONCC ESU.