18. Lower Klamath River Population

Central Coastal Stratum

Core, Functionally Independent Population

High Extinction Risk

Population likely below depensation threshold

5,900 Spawners Required for ESU Viability

492.3 mi^2 watershed (40% Federal ownership)

205 IP-km (127 IP-mi) (28% High)

Dominant Land Use is Timber Harvest

Key Limiting Stresses are 'Altered Sediment Supply' and 'Lack of Floodplain and Channel Structure'

Key Limiting Threats are 'Agriculture' and 'Channelization/Diking'

Highest Priority Recovery Actions

• Increase large woody debris (LWD), boulders, or other instream structure • Construct off-channel habitats, alcoves, backwaters, and old stream oxbows • Re-connect existing off channel ponds, wetlands, and side channels	• Remove, setback, or reconfigure levees and dikes • Reduce road-stream hydrologic connection • Increase beaver abundance

18.1 History of Habitat and Land Use

For over a century, timber harvest has been the dominant land use within the Lower Klamath River (LKR) sub-basin. Small-scale commercial harvest began in the mid- to late-1890s, while intensive timber harvest began in the 1950s with a peak harvest in the late 1960s. By 1969, approximately 50 percent of the sub-basin was logged, and by 1994 almost all of the remaining old-growth was logged, including riparian zones (Gale and Randolph 2000). Analysis of aerial photographic data indicated that 90 percent of the sub-basin was logged between 1948 and 1997, and the watersheds most impacted by timber harvest included South Fork Ah Pah, Surpur, Morek, Tully, and Johnsons creeks (Gale and Randolph 2000). As timber harvest increased, so did road construction. By 1994, the road density in the sub-basin was 5.3 miles of road per square mile of land, with an associated 7,249 road-stream crossings. Stemming from this period of timber harvest and road building was an increased frequency in landslides and debris torrents. Between 1948 and 1997, there were: (1) about 1,729 landslides, 760 of which could be linked to anthropogenic activities, and (2) approximately 255 debris torrents, with 131 linked to anthropogenic activities (Gale and Randolph 2000). The addition of lands in the lower LKR watershed to Redwood National Park in 1968, and again in 1978, brought about the cessation of timber harvest there, and improved road maintenance and decommissioning.

Today, Green Diamond Resource Company (GDRC, formerly Simpson Timber Company) conducts the majority of timber harvest in the sub-basin and operates under a Habitat Conservation Plan (GDRC 2006). The principal human population centers that are near fish-bearing tributaries include Requa, Klamath and Klamath Glen in the lower portion of the sub-basin, and Wautek (Johnsons) and Pecwan in the upper portion of the sub-basin. The arrival of Europeans brought about the quick extirpation of beavers in low-gradient riparian habitat, including the Lower Klamath estuary (WATER Institute 2014). The loss of beaver dams and ponds reduced rearing habitat opportunities for salmonids.

Other activities have also played a role in the sub-basin history with rural residential development occurring concurrently with the timber harvest. The principal human population centers that are near fish-bearing tributaries include Requa, Klamath and Klamath Glen in the lower portion of the sub-basin, and Wautek (Johnsons) and Pecwan in the upper portion of the sub-basin. Although only a small portion of the sub-basin is suitable terrain for agriculture, conversion of land for farming and ranching resulted in a loss of floodplain habitat in the LKR, including the estuary, which reduces available rearing habitat for juvenile coho salmon. Flood protection for residential communities along the Lower Klamath, construction of the original Redwood Highway, and then construction of the Highway 101 bypass further reduced both floodplain and riparian habitat. Small-scale gravel mining and water diversions have also had localized impacts on the habitat in the LKR (Gale and Randolph 2000) by causing sediment disturbance and potentially increasing sediment deposition onto coho salmon redds in the tributaries or reducing the tributary instream flows.

In addition to anthropogenic activities, floods over the last 150 years have also greatly affected stream channels and riparian ecosystems on the LKR mainstem (Harden et al. 1978, Kelsey 1980, Lisle 1981, 1989). These floods mobilized large amounts of sediment, led to substantial channel aggradation and widening, removed critical riparian forests, and resulted in subsequent loss of LWD (Payne and Associates 1989, Gale and Randolph 2000).

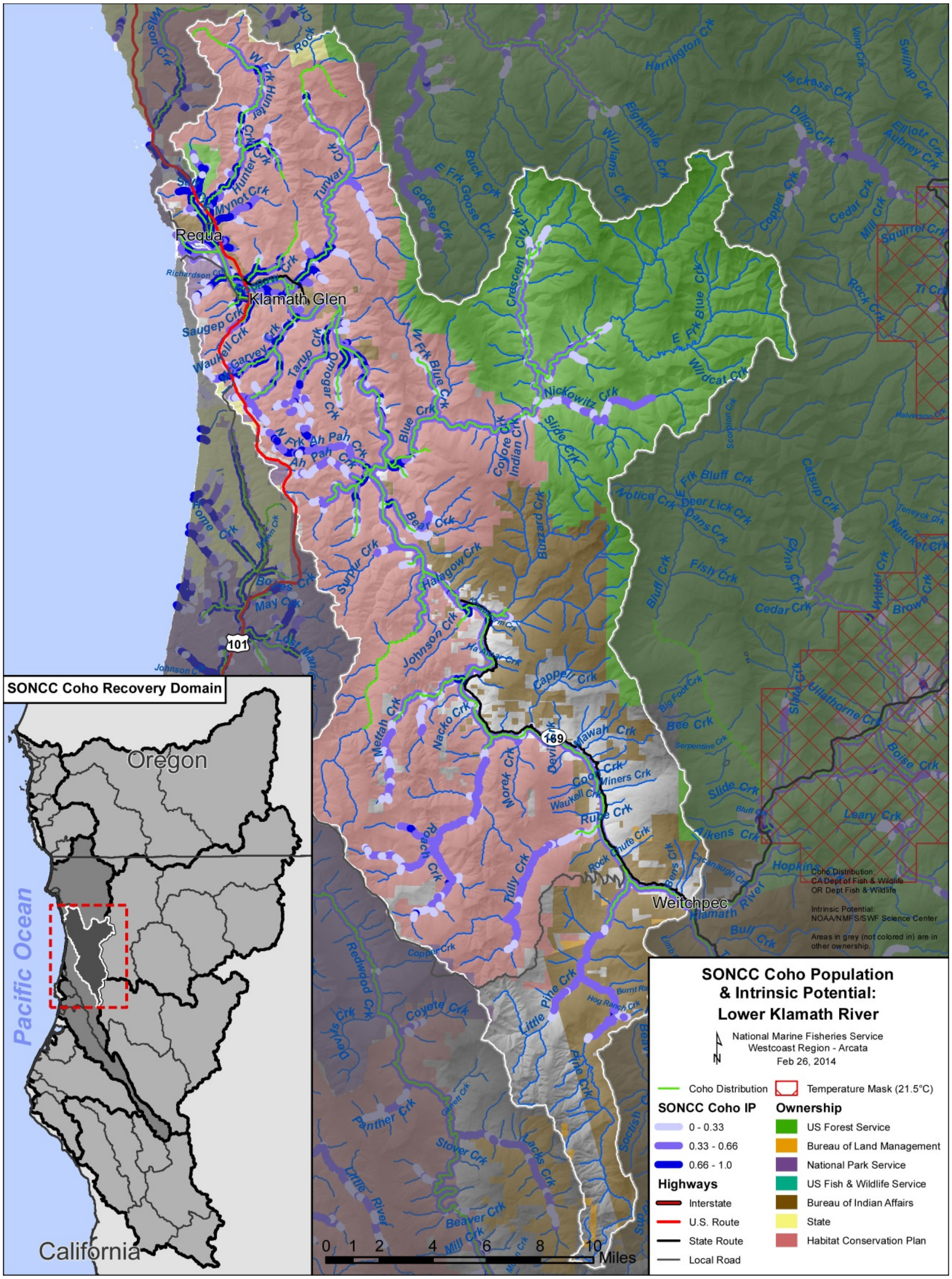

Figure 18-1. The geographic boundaries of the Lower Klamath River coho salmon population. Figure shows modeled Intrinsic Potential of habitat (Williams et al. 2006), land ownership, coho salmon distribution (CDFG 2012a), and location within the Southern-Oregon/Northern California Coast Coho Salmon ESU and the Northern Coastal diversity stratum (Williams et al. 2006). Grey areas indicate private ownership.

18.2 Historic Fish Distribution and Abundance

There is little information on the historic size of the LKR coho salmon population. The commercial gill-net fishery in the LKR caught 11,162 coho salmon (83,836 pounds) between late September and late October 1919 (Snyder 1931). The estimated annual sport fishery catch in the LKR was 1,187 coho salmon in 1951 (Gibbs and Kimsey 1955) and 4,000 coho salmon in 1954 (McCormick 1958). The proportion of coho salmon caught in the aforementioned fisheries that originated from the LKR coho salmon population is unknown. The California Department of Fish and Wildlife (CDFW; formerly California Department of Fish and Game [CDFG]) reported that in the 1960s, approximately 8,000 coho salmon returned to the mainstem Klamath River and tributaries (excluding the Shasta, Scott, Salmon and Trinity rivers; Taylor 1978, CDFG 2004b). The percentage of these fish that originated from the LKR coho salmon population is also unknown.

CDFW and U.S. Fish and Wildlife Service (USFWS) records (1945 to 1993) note the presence of coho salmon in Hunter, Hoppaw, Saugep, Terwer, McGarvey, Tarup, Blue, Bear, Tectah, and Roaches creeks (Voight and Gale 1998). Presence and abundance in these streams varied among years and was largely dependent on plantings of coho salmon fingerlings by CDFW. Although most of these plantings were fish from the sub-basin, 20,000 out-of-basin coho salmon from Alsea River, Oregon, were planted in McGarvey Creek between 1962 to 1963 (Voight and Gale 1998). About 150,000 coho salmon fingerlings were planted in Tarup, McGarvey, Hunter, Surpur, and Tectah creeks between 1962 and 1990 (Table 18-1). Planting of coho salmon peaked in the late 1960s and some stocked sub-basins were more successful than others (Voight and Gale 1998). The current population of LKR coho salmon may be partial descendants of these planted fish.

Table 18-1. Number of coho salmon fingerlings planted in Lower Klamath River tributaries (Voight and Gale 1998).

Creek	Number Coho Salmon Fingerlings Planted	Years	Origin	Program
Tarup	50,000	1968-1990	Unknown	CDFW & BIA
McGarvey	20,000	1962-1963	Alsea River, OR	CDFW
Hunter	2,000	1989	Unknown	CDFW & BIA
Surpur	10,000	1969	Unknown	CDFW
Tectah	60,000	1966-1968	Unknown	CDFW

Data on fish rescue in LKR tributaries provide some additional information about the past abundance of coho salmon in the population area. For example, 152 to 25,226 juvenile coho salmon were rescued in Hunter Creek between 1939 and 1945, 380 to 3,537 coho salmon juveniles were rescued in High Prairie Creek from 1950 to 1952, and 10,000 juvenile coho salmon were rescued in Mynot Creek in 1940 (Shapovalov 1941). The number of juvenile coho salmon rescued from Terwer Creek ranged from 318 to 13,685 from the 1940s through the early 1950s (Brown and Moyle 1991). In 1989, juvenile coho salmon were observed during fish surveys in McGarvey, Tarup, Tectah, Roaches and Ah Pah creeks, but there were less than 10 individuals per creek (Brown and Moyle 1991).

Williams et al. (2006) concluded, based on the model results to predict the IP coho salmon habitat, that coho salmon habitat included most LKR tributaries (Figure 18-1; Table 18-2). Further, most of the high IP reaches are in the lower (downstream) tributaries.

Table 18-2. Tributaries with high IP reaches (IP > 0.66), (Williams et al. 2006).

Stream Name	Stream Name	Stream Name
Hunter Creek	Richardson Creek	Salt Creek
Mynot Creek	Omagaar Creek	High Prairie Creek
Spruce Creek	Ah Pah Creek	Bear Creek
Panther Creek	N. Fork Ah Pah Creek	Blue Creek
McGarvey Creek	Tarup Creek	Mettah Creek
West Fork McGarvey Creek	Waukell Creek	Johnson Creek
Terwer Creek	Saugep Creek	Hog Ranch Creek
Hoppaw Creek	Junior Creek	Roaches Creek
Pine Creek		

In addition to providing connectivity to tributary watersheds for spawning and rearing, the mainstem LKR provides migratory and rearing habitat for adult and juvenile coho salmon for all Klamath River coho salmon populations. No extensive records exist on the production of coho salmon in this population, but available information indicates that the coho salmon population declined during the 20th century, and remains low (Brown and Moyle 1991, Soto et al. 2008a, Hillemeier et al. 2009, Silloway 2010).

18.3 Status of Lower Klamath River Coho Salmon

Spatial Structure and Diversity

The Yurok Tribe, CDFW, and GDRC conducted fish surveys over the past several decades, which provide data to assess, to some degree, the spatial structure of the LKR coho salmon population. Between 1996 and 2004, coho salmon were found in nearly all surveyed streams, including Salt, High Prairie, Hunter, Hoppaw, Saugep, Waukell, Terwer, McGarvey, Tarup, Omagaar, Blue, Ah Pah, Bear, Surpur, Little Surpur, Pularvasar, One Mile, Tectah, Johnsons, Pecwan, Mettah, Roaches, Cappell, Richardson, and Tully creeks (Table 18-3). Coho salmon were generally not well distributed in tributaries upstream of Blue Creek, although many of these creeks contain moderate to high IP (e.g., Mettah, Roaches, Tully, and Pine creeks; Gale et al. 1998). In general, coho salmon were only observed in the lower reaches of most tributaries, and in some cases the Yurok Tribe noted that their presence appeared to be non-natal rearing (Voight and Gale 1998, Yurok Tribal Fisheries Program [YTFP] 2009b).

Surveys in 1996 did indicate well-distributed coho salmon in McGarvey and Blue creeks, with observed patterns similar to historical reports. However, the distribution of juveniles appeared diminished compared to historical accounts in Hunter, Hoppaw and Tarup creeks (Voight and Gale 1998). Blue Creek was the only tributary where moderate numbers of juvenile and youngof-year (YOY) coho salmon were consistently observed. Three Blue Creek tributaries are important to anadromous salmonid spawning and rearing, including West Fork Blue Creek, Nickowitz Creek, and Crescent City Fork Blue Creek (Gale 2009c), which is the largest and lowest gradient tributary accessible to anadromous fish in the Blue Creek watershed (Figure 18-1). Large numbers of YOY coho salmon were also observed in Ah Pah Creek in 1997, but abundance was variable during subsequent years (Gale and Randolph 2000).

Because of the high incidence of non-natal rearing, juvenile survey data cannot be used to determine the distribution of the LKR population. Spawner distribution data provide more accurate information regarding natal population distribution. Spawning data from a few of the major tributaries in the LKR show moderate spawner densities throughout surveyed reaches of these watersheds. Spawning coho salmon have been found in Blue Creek (mainstem), Crescent City Fork of Blue Creek, Hunter, Waukell, McGarvey, Terwer, Ah Pah, Tectah, and Pine (Gale 2009a, 2009b; Beesley 2010). Blue Creek is the largest and most resilient LKR watershed and correspondingly supports the largest anadromous fish populations in the sub-basin (Gale and Randolph 2000). Habitat surveys in other creeks have shown only marginal habitat suitability for coho salmon spawning, primarily due to the high embeddedness of spawning gravels (Voight and Gale 1998), and lack of channel structure (e.g., fluvial stored wood) required to facilitate necessary gravel sorting and retention dynamics (Beesley and Fiori 2007a, 2008a).

Table 18-3. Tributaries in the Lower Klamath River population with relatively recent coho salmon presence. Based on surveys by CDFW and YTFP 1990 to 2008 (Gale and Randolph 2000).

Stream Name	Stream Name	Stream Name
Salt Creek	Ah Pah Creek	Tully Creek
Hunter Creek	Pularvasar Creek	McGarvey Creek
Mynot Creek	Junior Creek	Omagaar Creek
Hoppaw Creek	Johnsons Creek	High Prairie Creek
Terwer Creek	Richardson Creek	Little Surpur Creek
Tarup Creek	Blue Creek	One Mile Creek
Saugep Creek	Bear Creek	Cappell Creek
Waukell Creek	Surpur Creek	Pecwan Creek
Tectah Creek	Mettah Creek	Roaches Creek

For the LKR coho salmon population to be at low risk for the population size threshold, Williams et al. (2008) estimated that a minimum of 29 coho salmon per IP-km of habitat are needed (5,900 spawners total). The current distribution of spawners is well below this threshold. With the exception of McGarvey and Blue Creeks (Gale and Randolph 2000), coho salmon are not well distributed throughout the Lower Klamath tributaries, and continue to occur at modest to very low densities.

Based on what is known from survey data about the life history and genetic diversity of the LKR population, this population has been affected by out-of-basin stock planting and hatchery influences. The reduced population abundance has likely led to depensation effects in some years (e.g. inbreeding) and reduced genetic diversity. However, compared with other Klamath populations, tributaries in the LKR sub-basin may support some of the healthiest wild coho salmon in the basin. The population has a relatively high capacity for life history plasticity based on the diversity of unique habitat features and that historically, the population could have had a wide array of life history strategies that utilized diverse tributary and estuary habitats during various times of the year.

Population Size and Productivity

Coho salmon have a wide distribution throughout the Lower Klamath, but almost always low abundances, based on the results of juvenile surveys, spawner surveys, and outmigrant trapping (Voight and Gale 1998, Gale and Randolph 2000, GDRC 2006, YTFP 2009a). Moderate densities of coho salmon are found in Blue, McGarvey and Ah Pah creeks. Age 1+ coho salmon have also been captured or observed in the Lower Klamath River and overwintering survival has been estimated at between 27 and 76 percent with an average of 47 percent (Ackerman et al. 2006, Voight and McCanne 2006).

Surveys have been conducted on many LKR tributaries and the results indicate a low, but relatively constant abundance of juveniles (Voight and McCanne 2002, Mohr and Hankin 2005, GDRC 2009). Juvenile coho salmon abundance in Hunter Creek and East Fork Hunter Creek has fluctuated widely (from 0 to 6,000 individuals) from year to year throughout the last decade. Average estimated abundance is approximately 2,000 individuals per year in Hunter Creek (GDRC 2009). Ah Pah Creek had an estimated average of 3,500 juveniles between 2007 and 2008 (GDRC 2009). Juvenile coho salmon abundance was estimated by Ackerman et al. (2006) to be between 15 and approximately 46,200 individuals from 2002 to 2006.

Consistent spawner data are only available from Blue Creek, but these data provide a relatively long period of productivity and abundance information for the population (Gale et al. 1998, Gale 2009c). Between 1995 and 2008, 2,562 adult coho salmon were observed (Figure 18-2). Observed numbers of spawners ranged from 4 in 1995 to 1,040 in 2002. Approximately two percent of observed returns were jacks during this period. Although these surveys did not sample the full run of coho salmon, they can provide some indication of coho salmon production from Blue Creek.

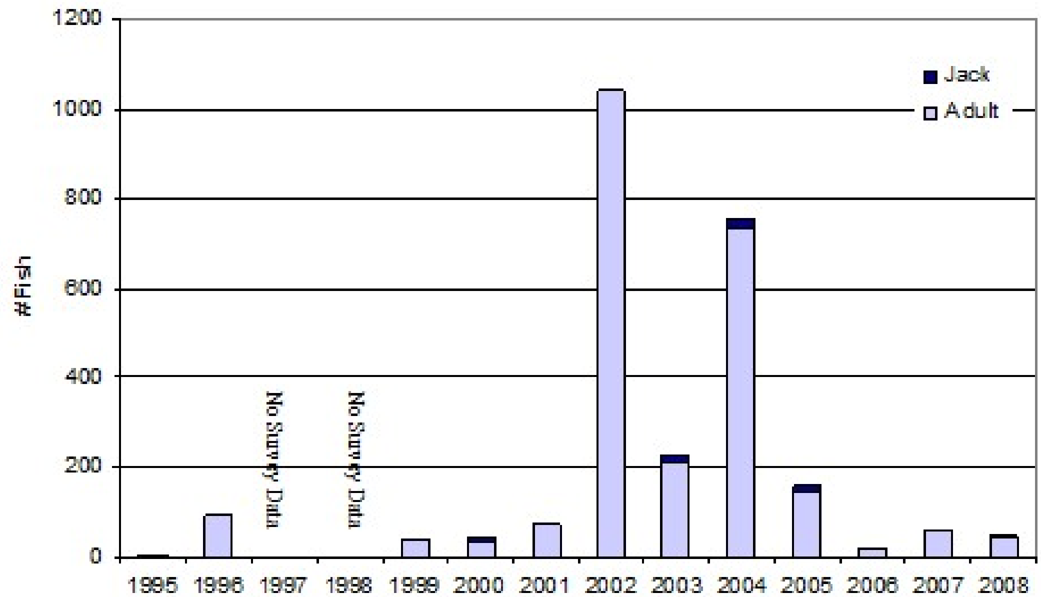

Figure 18-2. Coho salmon observed spawning in the Blue Creek watershed of the Lower Klamath River sub-basin between 1995 and 2008. Data are from YTFP snorkel surveys (Gale et al. 1998, Gale 2009c).

Adult coho salmon population abundance, estimated by Ackerman et al. (2006), ranged from 14 to approximately 1,500 spawners between 2002 and 2006, based on juvenile coho salmon abundance in the Lower Klamath River (Table 18-4) and an assumed 10.2 percent marine survival. There does not appear to be a significantly strong or weak year class based on these estimates, which is supported by the Blue Creek spawner data.

Table 18-4. Estimates of sub-yearling and adult coho salmon abundance in Lower Klamath River tributaries (Voight and McCanne 2002, 2006; Ackerman et al. 2006). Juvenile abundance estimates are for two years prior to the adult return year.

Adult Return Year	Mean Juvenile Abundance	95% CI Juvenile Abundance	Mean Adult Abundance	95% CI Adult Abundance
2001	--	--	512[1]	--
2002	322	15 – 628	14	1 – 28
2003	13,089	8,062 – 18,115	574	354 – 795
2004	33,812	21,433 – 46,191	1,483	940 – 2,026
2005	21,188	10,529 – 31,847	929	462 – 1,397
2006	7,188	499 – 13,877	315	22 – 609

[1] Estimate assumed based 2.89 recruits per spawner in Trinity for 2001 brood.

Williams et al. (2008) determined at least 205 coho salmon must spawn in the LKR sub-basin each year to avoid effects of extremely low population sizes. Based on criteria established by Williams et al. (2008), the Lower Klamath River population is at high risk of extinction because the spawner abundance has likely been below the depensation threshold of 205 (Figure 18-2).

The productivity of the population, based on the juvenile and adult abundance estimates, appears to be declining. Historical data indicate that the Lower Klamath coho salmon population was more abundant as recently as 50 years ago (Brown and Moyle 1991) and results of recent data suggests that this population has experienced low, highly variable abundances over the past decade (Voight and McCanne 2004, Garwood 2012). The population has likely experienced negative population abundance over the past 50 years and even recent strong returns in some tributaries have not sustained any positive population growth in the population. Because the productivity of the population appears negative, the population is at increased risk of extinction.

Extinction Risk

The Lower Klamath River population is at high risk of extinction because NMFS estimates the ratio of the three consecutive years of lowest abundance within the last twelve years to the amount of IP-km in a watershed is less than one, the criterion described by Williams et al. (2008). NMFS' determination of population extinction risk is based on the viability criteria provided by Williams et al. 2008 (Table 3, pg. 17). These viability criteria reflect population size and rate of decline. As Williams et al. (2008) provided no viability criteria for assessing moderate and high risk based on spatial structure and diversity, spatial structure and diversity were not considered in NMFS' determination of population extinction risk.

Role of Population in SONCC Coho Salmon ESU Viability

The Lower Klamath River population is a core, Functionally Independent population within the Central Coastal diversity stratum; historically having had a high likelihood of persisting in isolation over 100-year time scales, and with population dynamics or extinction risk over a 100-year time period that are not substantially altered by exchanges of individuals with other populations (Williams et al. 2006). Though strays have minimal influence on the LKR population, this sub-basin facilitates straying because of its downstream location in the Klamath River and the number of independent populations in close proximity along the coast. In addition to spawning and rearing habitat, the Lower Klamath River is important for populations throughout the Klamath and Trinity sub-basins. Coho salmon juveniles and smolts from upstream populations use the Lower Klamath River sub-basin during the summer and winter for rearing and acclimation, and adults use thermal refugia for holding prior to migrating upstream (Voight and Gale 1998, YTFP 1999, Belchik and Turo 2002, Soto et al. 2008a, YTFP 2009a, Hillemeier et al. 2009, Silloway 2010).

To contribute to stratum and ESU viability, the Lower Klamath River core population should have at least 5,900 spawners. Sufficient spawner densities are needed to maintain connectivity and diversity within the stratum and continue to represent critical components of the evolutionary legacy of the ESU. Besides its role in achieving demographic goals and objectives for recovery, as a core population the Lower Klamath River population may serve as a source of spawner strays for nearby coastal populations as well as upstream populations in the Klamath basin. At present, the capacity of the Lower Klamath River coho salmon population to provide recruits to adjacent independent populations is limited due to its low spawner abundance. Conversely, recruits straying from nearby rivers may enhance recovery of the Lower Klamath River population.

18.4 Plans and Assessments

U.S. Forest Service- Orleans District

Watershed Condition Framework

http://www.fs.fed.us/publications/watershed/Watershed_Condition_Framework.pdf

The Watershed Condition Framework (WCF) is a comprehensive approach for proactively implementing integrated restoration on priority watersheds on national forests and grasslands, including the Lower Klamath River. The WCF provides the Forest Service with an outcome-based performance measure for documenting improvement to watershed condition at forest, regional, and national scales.

State of California

Recovery Strategy for California Coho Salmon

http://www.dfg.ca.gov/fish/Resources/Coho/SAL_CohoRecoveryRpt.asp

The Recovery Strategy for California Coho Salmon was adopted by the California Fish & Game Commission in February 2004 and is a guide for recovering coho salmon on the north and central coasts of California, including the Lower Klamath River. The Recovery Strategy emphasizes cooperation and collaboration at many levels, and recognizes the need for funding, public and private support for restorative actions, and maintaining a balance between regulatory and voluntary efforts.

Yurok Tribe

Yurok Tribal Fisheries Program – Lower Klamath Division - Restoration Plans

Lower Klamath River Sub-basin Watershed Restoration Plan.

The Lower Klamath River sub-basin watershed restoration plan (Gale and Randolph 2000) prioritizes upslope restoration and identified tributary specific restoration objectives for a majority of Lower Klamath tributaries. Since 2000, YTFP and the Yurok Tribe Watershed Restoration Program (YTWRP) have been working cooperatively with restoration partners to revise and implement the sub-basin restoration plan and meet program objectives.

Restoration Planning in Lower Blue Creek, Lower Klamath River: Phase 1.

The Restoration Planning in Lower Blue Creek report (Beesley and Fiori 2008a) describes factors currently limiting salmonid production in lower Blue Creek and presents site-specific restoration strategies that address identified limiting factors.

Geomorphic and Hydrologic Assessment and Restoration Planning in the Salt Creek Watershed, Lower Klamath River Sub-basin, California.

The geomorphic and hydrologic assessment report (Beesley and Fiori 2007a) describes factors currently limiting salmonid production in the Salt Creek watershed and presents several potential restoration options for improving watershed function and salmonid productivity.

Cooperative Restoration of Tribal Trust Fish and Wildlife Habitat in Lower Klamath River Tributaries.

The cooperative restoration report (Beesley and Fiori 2008b) describes factors currently limiting salmonid production in several priority Lower Klamath tributaries and presents site-specific restoration strategies that address identified limiting factors.

Yurok Tribe Environmental Program - Restoration Plans

Klamath River Estuary Wetlands Restoration Prioritization Plan.

The Klamath River estuary wetlands restoration plan (Patterson 2009) applies the California Rapid Assessment Method (CRAM) to assess the ambient condition of wetland complexes in the Klamath River Estuary. The method provides a standardized numerical scoring system for wetland attributes that was used to prioritize sites for wetland mitigation and restoration projects.

Green Diamond Resource Company

Habitat Conservation Plan

About 65 percent of the LKR sub-basin is private land; the majority of which is owned by Green Diamond. The Aquatic Habitat Conservation Plan (HCP), finalized in 2006 and valid through 2056, was developed in accordance with the ESA section 10 and contains a conservation strategy to minimize and mitigate the potential adverse effects of any authorized taking of aquatic species that may occur incidental to Green Diamond's activities; to ensure that any authorized take and its probable impacts will not appreciably reduce the likelihood of survival and recovery in the wild of aquatic species; and contribute to efforts to reduce the need to list currently unlisted species under the ESA in the future by providing early conservation benefits to those species. The plan has a number of provisions designed to protect coho salmon and salmon habitat throughout the Lower Klamath. More information about HCPs in the Lower Klamath River can be found in Section 3.2.5.

Redwood National and State Parks

Watershed Rehabilitation Plan (1981)

Management Alternatives of the Redwood Creek Estuary (1983)

Redwood National and State Parks, Humboldt and Del Norte Counties: Final General Management Plan/General Plan, environmental impact statement/environmental impact report - USDI National Park Service and California Department of Parks and Recreation (1999)

Road Strategy: Access and Treatment Priorities for Parkland in the Redwood Creek Watershed (2005)

Planning and strategy documents from RNSP focus on ecosystem restoration, especially road removal and forest restoration efforts. Between 1978 and 2010, RNSP removed 266 miles of roads from Park lands, with 114 miles of road remaining to be treated.

18.5 Stresses

Table 18-5. Severity of stresses affecting each life stage of coho salmon in the Lower Klamath River. Stress rank categories, assessment methods, and data used to assess stresses are described in Appendix B.

	Stresses	Egg	Fry	Juvenile[1]	Smolt	Adult	Overall Stress Rank
1	Altered Sediment Supply[1]	High	Very High	Very High[1]	Very High	High	Very High
2	Lack of Floodplain and Channel Structure[1]	High	Very High	Very High[1]	Very High	High	Very High
3	Degraded Riparian Forest Conditions	High	High	High[1]	High	High	High
4	Impaired Estuary/Mainstem Function	-	Low	High[1]	High	High	High
5	Altered Hydrologic Function	Medium	Medium	High[1]	High	High	High
6	Impaired Water Quality	Low	Medium	High[1]	Medium	Medium	Medium
7	Adverse Hatchery-Related Effects	Medium	Medium	Medium	Medium	Medium	Medium
8	Increased Disease/Predation/Competition	Low	Low	High	High	Medium	High
9	Barriers	-	Low	Medium	Medium	Medium	Medium
10	Adverse Fishery- and Collection-Related Effects	-	-	Low	Low	Medium	Low

[1]Key limiting stresses and limited life stage.

Key Limiting Stresses, Life Stages, and Habitat

The key limiting stresses for this population are altered sediment supply and lack of floodplain and channel structure, as they have the greatest impact on the population's ability to produce sufficient spawners to support recovery. The juvenile life stage is most limited and quality winter rearing habitat, as well as summer rearing habitat, is lacking for the population. Juvenile summer rearing habitat is impaired mostly from subsurface flow conditions in the tributaries and poor water quality of the mainstem Klamath River (e.g., high water temperatures resulting from degraded riparian conditions and water withdrawals upstream). Winter rearing habitat is severely lacking because of channel simplification, disconnection from the floodplain, degraded riparian conditions, poor large wood availability, and an estuary which has been altered and reduced in size due to development, channelization, and diking. Large wood has been removed and is not naturally replacing at the rates required to maintain key components of habitat complexity. An altered sediment supply in many tributaries has hindered fish passage, resulted in poor summer survival, poor spawning and incubation habitat suitability, and the loss and degradation of stream and off-channel habitat. Most potential spawning reaches have excessively embedded and armored substrate, making redd construction more challenging for adults and reducing permeability in constructed redds. The combination of high rates of sedimentation, lack of channel structure (e.g., LWD) and resilient riparian forests, and impaired hydrologic function have led to subsurface flows in many LKR tributaries during periods of low to no precipitation, resulting in high stranding and mortality rates and reduced growth (Hillemeier et al. 2009). Channel sedimentation and lack of channel structure (e.g., LWD) have caused significant loss to overwintering and summer rearing habitat as well (Gale and Randolf 2000, Beesley and Fiori 2007b). In many streams, the dewatering of tributary reaches substantially reduces summer and even winter (e.g., during periods of low or no precipitation) rearing habitat and can occur so quickly that juveniles are unable to relocate. YTFP has documented substantial anadromous fish mortality associated with seasonal tributary drying events (Beesley 2010).

In terms of floodplain and channel structure, the cumulative cascading effects from high rates of sedimentation, lack of fluvial recruited/deposited wood, and changes in run-off processes (as a result of road building and timber harvest activities) have altered floodplain formation processes. Repeated channel avulsion and valley mobilizing events and subsequent long-term channel incision has resulted in coarsening of floodplain and instream sediments, decreased floodplain hydrologic connectivity, and chronic riparian forest dysfunction. Long-term channel incision in the lower reaches of many tributaries has resulted from a lack of channel structure and has led to a coarsening of bed materials and likely reduced the amount of suitable salmonid spawning gravels. Off-channel habitat (e.g., backwaters, alcoves, or inundated floodplains) used as refugia also become increasingly limited and hydrologically disconnected during periods of long-term channel incision.

Channel simplification (primarily lack of channel structure and LWD from the loss of riparian resiliency) and the lack of floodplain and off-channel habitat availability result in most tributary stream reaches having minimal refuge habitat from elevated winter flows, turbidity, or both. This in turn causes fish to be either flushed downstream and out into the mainstem river, to have greatly reduced growth rates due to excessive energy expenditure in the increased velocities, or to perish. This also puts increased demand on river and estuary off-channel habitat as fish pushed into the mainstem search for suitable low-velocity rearing habitat. Additionally, increased turbidity in many tributaries during high flow likely hinders winter/spring feeding potential and growth (Sigler et al. 1984).

In many tributaries, repeated aggradation and degradation has also led to floodplain conditions that preclude the establishment of viable and resilient riparian forests, which results in poor LWD recruitment that perpetuates these conditions. LWD serves many different and critically important functions in a watershed. Channel stored wood can alter sediment storage and delivery dynamics, dampen peak flows, facilitate the formation and maintenance of critical salmonid habitats (e.g., spawning beds and pools), and provide cover for fish and other aquatic dependent species. Accumulations of large wood have been observed to be a significant component in floodplain and terrace deposits and help maintain complex instream and floodplain habitat. Fluvial deposited wood has also been attributed to the development of viable and resilient riparian forests.

While all life stages are affected by stresses, the most limited is the juvenile life stage. Summer rearing is inhibited by the lack of complex instream habitat (e.g., deep pools and LWD) and the loss of summer habitat due to low and subsurface flow conditions in tributaries. Overwinter rearing is inhibited by the lack of complex instream habitat (e.g., deep pools and LWD) and lack of off-channel habitat. The loss of suitable rearing habitat is a key limiting factor for this population and contributes to low productivity. In addition, the lack of channel structure (e.g., LWD) contributes to low spawning gravel from the lack of gravel retention and sorting.

The primary limiting habitat types for the LKR population are high quality spawning and rearing habitat. While the areas that provide valuable rearing habitat can be different from those areas that may provide spawning habitat, a few key tributaries in the Lower Klamath provide the majority of these habitats to the population. These important tributaries include Tectah, Terwer, Salt, Waukell, Hunter, McGarvey, and Blue creeks. Small pockets of high quality spawning and rearing habitat also exist in Ah Pah, Mettah, Johnsons, High Prairie, Hoppaw, and Surpur, and Tarup creeks. For non-natal populations and for some natal fish, the mainstem, estuary, and lower reaches of several Lower Klamath tributaries offer refugia areas that also provide vital habitat for growth and survival (Table 18-6).

As the largest and most intact tributary in the Lower Klamath, Blue Creek is an area where extensive vital habitat exists and therefore an essential area for recovery. Although the lower reaches of Blue Creek have been heavily impacted, the majority of the upper watershed and Crescent City Fork is protected on National Forest lands as wilderness or Late Successional Reserve. The upper Blue Creek drainage contains the highest quality habitat and riparian conditions of all the Lower Klamath tributaries. The Blue Creek wild coho salmon stock represents an important genetic stronghold for the LKR coho salmon population (Gale et al. 1998).

Summer rearing habitat in many LKR tributaries and off-channel areas is also important for coho salmon (Hillemeier et al. 2009, Silloway 2010). Because of seasonally elevated water temperatures in most of the mainstem Klamath River, these tributaries and off-channel areas can serve as thermal refugia during the summer, which can be important for juveniles that have been displaced from other habitat and are forced to rear in the mainstem or estuary or migrate through these habitats to reach the ocean. Refugia are also used by adult fish that enter the Klamath early in the spawning season. Because many tributaries go subsurface, the majority of available thermal refugia are at tributary mouths. Thermal refugia are important for non-natal coho salmon in the mainstem Klamath River. Low velocity refugia are important for non-natal and natal juvenile coho salmon that get flushed out of or actively leave their natal creeks (Soto et al. 2008a, Hillemeier et al. 2009, Hiner et al. 2011, Silloway and Beesley 2011, Pagliuco et al. 2011, Fiori et al. 2011a, Fiori et al. 2011b, YTFP 2012).

Table 18-6. Potential vital habitat within the geographic boundaries of the Lower Klamath River sub-basin.

Stream Name	Stream Name	Stream Name
Hunter Creek[1,2]	Morek Creek[2]	Waukell Creek[1,2,3]
Mynot Creek[1]	Ah Pah Creek[1,2]	Saugep Creek[1,2,3]
Spruce Creek[1,2,3]	N. Fork Ah Pah Creek[1]	Junior Creek[1,2,3]
Panther Creek[1,2,3]	Tarup Creek[1,2]	Salt Creek[1,2,3]
McGarvey Creek[1,2,3]	Tectah Creek[1,2]	High Prairie Creek[1]
West Fork McGarvey Creek[1]	Blue Creek[1,2]	Bear Creek[1]
Terwer Creek[1,2]	Crescent City Fork[1,2]	Roaches Creek[2]
Hoppaw Creek[1]	East Fork Blue[1,2]	Mettah Creek[1]
Richardson Creek[1,2,3]	West Fork Blue[1,2]	Johnsons Creek[1]
Pine Creek[1,2]	Estuary Sloughs[1,2,3]	Cappell Creek[2]
East Fork Hunter[1]	South Fork Ah Pah[1]	Nickowitz[1,2]
East Fork Terwer[1]	Surpur[12]	
[1]High Quality Spawning and/or Rearing Habitat [2]Thermal refugia [3]Flow refugia		

Altered Sediment Supply

Altered (increased) sediment supply represents one of the greatest stresses to the population due to the high degree of sediment loading and aggradation that occurs in LKR tributaries. Past and ongoing increased sediment supply in the LKR sub-basin reduced quantity and quality of coho salmon habitat for all life stages; therefore, NMFS considers altered sediment supply to be an overall very high stress. Timber harvest, removal of riparian and instream LWD, and road building (when combined with the naturally erodible geology of the area and large floods), have resulted in substantial streambed sedimentation, excessive channel widening, loss of riparian forests, and an overall reduction in the quality and quantity of instream fish habitat. Mass wasting is common in the region and causes more downslope movement of material than any other geologic process—including stream action (Harris and Tuttle 1984). Such a high degree of sedimentation combined with the loss of fluvial stored LWD and resilient riparian forests, hinders successful spawning of adult coho salmon and emergence of fry, limits access to rearing habitats, increases competition and predation, and reduces macroinvertebrate densities (Gale and Randolph 2000, Beesley and Fiori 2007b). In over one-half of surveyed stream pool tailouts, embeddedness (as a percent occurrence) exceeded 50 percent and often reached 100 percent (Gale and Randolph 2000, GDRC 2006, 2009). Of the streams surveyed (in the 1990s) in the LKR sub-basin, the highest incidence of embeddedness (>50 percent) were in Roaches, Pecwan, Cappell, West Fork McGarvey, SF Mettah, Johnsons, and Mynot creeks (GDRC 2006). In 2007 to 2008, the frequency of highly-embedded reaches seemed to decrease and Mynot, Hoppaw, and Ah Pah creeks had the highest incidence of embeddedness. Some reaches within these creeks experience high sedimentation and may have unsuitable gravel for egg incubation and fry emergence.

In addition to reduced quality and quantity of spawning gravels, excessive sedimentation also results in the loss of coho salmon habitat and the loss of connectivity within tributaries due to intermittent periods of subsurface flow during periods of low to no precipitation (Beesley and Fiori 2007b). Subsurface flows in the lower reaches and at the mouths of tributaries are due to the interplay of several physical and hydrologic processes, including the timing of sediment transport in tributaries relative to the surface water elevation of the mainstem Klamath River. Deposition of suspended sediment and bedload originating from tributaries occurs when the water surface elevation of the Klamath River is higher than the elevation of the tributary channel. The majority of LKR tributaries flow subsurface during some part of the year (primarily from March to November). During spring and summer, there is a loss of rearing habitat and access to and from the upper watersheds. During the fall, spawning may be delayed in some tributaries due to a lack of access. Sediment from upstream watersheds is not only deposited in tributaries, but also downstream in the mainstem and estuary, forming point bars (where sloughs historically were present) and filling pools where coho salmon were once able to hold in the lower river (Beesley and Fiori 2007b).

Lack of Floodplain and Channel Structure

The lack of floodplain and channel structure in the LKR population area is a high to very high stress for all life stages, and is especially stressful to juvenile coho salmon. Most stream reaches are unstable, have simplified instream structure and habitat diversity, excessive erosion and aggradation, and lack suitable spawning gravels, resulting in reduced quality and complexity of instream habitat (Gale and Randolph 2000, Beesley and Fiori 2004, 2007a, 2007b, 2008a, 2008b, 2009). The index of D50 (a measure of median substrate size) can be used to evaluate floodplain and channel structure. Measurements of D50 from Blue, Terwer, and Hunter creeks show variable sediment characteristics between creeks. Although Terwer Creek had very good sediment characteristics, Blue and Hunter creeks had fair to poor spawning gravels (Beesley and Fiori 2008a). Seventy to ninety percent of the particles measured at riffle crests in lower Blue Creek were larger than the preferred median size range (14.5 – 35 mm; Kondolf and Wolman 1993) for salmonid spawning (Beesley and Fiori 2008a).

Recruitment of high quality LWD to fluvial habitats is critical to channel formation, floodplain connectivity, spawning gravel sorting, retention dynamics, and instream structure. Active removal of fluvial deposited wood and decades of no or low LWD recruitment has simplified stream and riparian forest complexity, reduced floodplain connectivity and productivity, and reduced the amount of off-channel habitat. The distribution and abundance of LWD in LKR tributaries has been surveyed by the YTFP and GDRC. YTFP found that LWD in the LKR tributaries ranged from 34 to 537 pieces/mile (average = 230; Gale and Randolph 2000). LWD is the primary cover type in only about 25 percent of LKR tributaries and the lowest densities of LWD (<100 pieces/mile) occurred in Morek, Cappell, and Slide Creek (Gale and Randolph 2000). Conifers comprise between 1 and 19 percent of the riparian canopy in Lower Klamath tributaries and the riparian forest is dominated almost exclusively by deciduous tree species, such as red alder (*Alnus rubra*). Alders are substantially inferior to conifers for maintaining channel stability and floodplain connectivity, and for creating and maintaining productive fluvial habitats for fish and wildlife. However, alders are still important for ecosystem functions in the riparian zone and as large wood in the stream.

Pool depth and frequency is another important characteristic of streams that provides information about instream habitat quality. Pools were infrequent in most surveyed tributaries (average = 20 percent of total stream length while very good conditions would have >50 percent). Pools were most infrequent in Mynot, Omagaar, Tarup, Bear, and Johnsons (GDRC 2006). Pools throughout LKR tributaries were generally shallow with only about 20 percent of pools >3 ft. deep (Gale and Randolph 2000). The tributaries with the lowest number of deep pools (>3 ft.) include Mettah, Bear, Ah Pah, Omagaar, Saugep, Hoppaw, Mynot, and High Prairie creeks. Shallow pool depths likely limit the rearing capacity in many streams. With respect to pool habitat complexity, the percentage of LWD providing structural shelter in pools reflects the quantity and quality of potential salmonid habitat, and possibly the effects of past management practices (GDRC 2006). Most pools lack LWD, especially in the West Fork Blue, Johnsons, Roaches, and Tully creeks (GDRC 2006). In general, the lack of functional instream and floodplain habitat hinders successful spawning and emergence, limits rearing capacity for juveniles, increases competition and predation, alters food webs, and leads to an overall decrease in growth and survival of coho salmon in the population (Gale and Randolph 2000, Beesley and Fiori 2007b, 2008a, 2008b).

Riparian Forest Conditions

Degraded riparian forest conditions are a high stress for all life stages of coho salmon in this population. Past timber harvest practices have resulted in the removal of nearly all mature conifers from tributary riparian areas (Gale and Randolph 2000). Riparian forests of LKR tributaries have not recovered from these activities, and in many cases, succession from deciduous (e.g., red alder) dominated riparian stands to conifer dominated forests is not occurring. Riparian forests comprised of mature native conifers, especially coastal redwoods, are critically important for creating and maintaining the complex, productive stream and floodplain habitats necessary to support Lower Klamath coho salmon populations. Redwood dominated riparian forests facilitate increased channel stability and stream bank protection, provide a continual supply of high quality LWD to fluvial habitats, filter and sort sediment and capture nutrients, provide substantial shade and instream cover, and support complex, self-maintaining stream and riparian food webs. The lack of mature, conifer dominated riparian forests and fluvial LWD recruitment in Lower Klamath tributaries and the mainstem has resulted in increased water temperatures, poor sediment sorting, storage, and delivery dynamics, simplified stream reaches and floodplain areas with low habitat quality (Gale and Randolph 2000). The poorest channel and riparian conditions have been noted in Waukell, Saugep, Surpur, and Little Surpur creeks (Gale and Randolph 2000); however, these conditions persist in virtually every Lower Klamath tributary, including Blue Creek (Beesley and Fiori 2008a).

Currently, conifers comprise less than one third of the riparian canopy along the mainstem lower Klamath River, and in a majority of the tributaries conifers make up less than 15 percent of the riparian canopy. Live conifers comprise less than 25 percent of the potentially recruitable LWD. Examples of a relatively healthy riparian forest include portions of upper Blue Creek where live conifers comprise between 27 and 77 percent of the total canopy and represent between 40 to70 percent of the potentially recruitable LWD (Gale and Randolph 2000). The lower reaches of Blue Creek, in contrast, exhibit poorly functional riparian areas due to channel incision and concurrent loss of floodplain connectivity, bank instability, and impacts resulting from feral cattle and past timber harvest practices in the watershed (Beesley and Fiori 2008a). The lack of riparian cover and forest regeneration in this area has impacted water quality (see below) and significantly reduced salmonid rearing capacity, especially during winter and spring (Beesley and Fiori 2008a).

Impaired Estuary/Mainstem Function

The Lower Klamath River mainstem and estuary provide migratory and rearing habitat for all populations of salmon in the Klamath Basin. Although the Klamath River estuary is relatively intact and unaffected by urban development, several factors limit its ability to support properly functioning habitat for coho salmon (Hiner and Brown 2004, NMFS 2007b, Beesley and Fiori 2004 and 2008b). This stress is regarded as high for this population of coho salmon in the Klamath Basin. The available rearing habitat has been reduced because of levee construction and channel realignment occurring in the Klamath River estuary and in the lower reaches of all of the off-estuary tributaries (e.g., Hunter-Salt Creek slough, Mynot Creek, Hoppaw Creek, and Waukell Creek slough). Large coastal wetlands in the Lower Klamath have been converted into grass pastures for cattle or farming, and the ability of streams to breach their banks and access floodplain habitats during flood events has been severely minimized, especially on the north side of the estuary (Gale and Randolph 2000, Beesley and Fiori 2004, 2008b). A large levee was also constructed around the Klamath Glen community after the 1964 flood and extends along the lower 0.5 miles of Terwer Creek. This levee and others in the lower river have eliminated juvenile access to floodplains, wetlands, and estuarine and tidally influenced sloughs that provide refugia and abundant food resources for rapid growth and increased survival. Patterson (2009) concluded that wetlands in the Klamath River estuary were degraded by various factors ranging from invasive species to cattle grazing and altered hydrology. Sedimentation in the estuary has also reduced quality of estuary habitat through the filling of pools and simplification of instream habitat. Little deep water or off-channel habitat exists in the estuary to provide refugia for coho salmon from high water temperatures in the summer/fall or high flows in the winter.

Mainstem function is a high stress for the LKR population and for other upstream populations due to the conditions encountered when migrating to and from the ocean and while staging and rearing prior to ocean entry. Water quality in the mainstem Klamath River is generally poor (e.g., high turbidity and stream velocities during winter and high water temperatures in summer/fall), and sedimentation from past and ongoing land use have led to substantial reductions in fluvial habitat complexity and loss of refugia. Water temperatures during summer and fall in the lower mainstem Klamath River often exceed upper tolerable thresholds for salmonids (see below). In addition to water quality, water withdrawals from the Klamath River and its major tributaries (e.g., Trinity, Shasta and Scott rivers) have altered the hydrologic regime and resulted in a lowered water table during summer and fall months. Connectivity with most tributaries in the Lower Klamath is impaired during the late summer and fall, and substantial precipitation is usually necessary before access is reestablished in the LKR tributaries for migrating adult salmonids (Beesley and Fiori 2007b). As juvenile coho salmon migrate downstream, the lack of adequate rearing habitat and refugia decreases opportunities for growth prior to ocean entry, which can ultimately influence ocean survival. Although this population has the shortest stretch of mainstem to pass through and has relatively good mainstem water quality compared to upstream reaches, the degradation of mainstem conditions and loss of estuarine habitat together constitute a high stress for this population.

Altered Hydrologic Function

Altered hydrologic function is a high stress for the population with the greatest impacts to juveniles, smolts, and adults which are impacted by altered hydrologic function in LKR tributaries (e.g., excessive sedimentation that results in subsurface flows) and an altered hydrograph in the mainstem Klamath River. The timing, magnitude and extent of flows in the Lower Klamath River from the confluence of the Trinity River to the estuary are altered compared to historic conditions. Generally, spring and summer flows are lower than in the past, while fall and winter flows in the Lower Klamath River are generally similar to historic conditions. The hydrologic function of tributaries in the Lower Klamath has also been altered, evidenced by lower portions of tributaries going dry from late spring to fall because of sediment aggradation. The removal of mature conifers from throughout the Lower Klamath has likely resulted in a change in the "wet season" stream hydrograph. In particular, this change in vegetative canopy and slope cover has likely resulted in more intense peak discharges of shorter duration following storm events (Beesley and Fiori 2007b).

Seasonal intermittent drying is the most common pattern observed in Lower Klamath tributaries (Gale and Randolph 2000, Beesley and Fiori 2007b). Most creeks begin drying up at the mouth in late spring/early summer and subsurface conditions progressively migrate upstream during summer/fall. Subsurface conditions are largely driven by the timing, duration, and magnitude of rainfall and river/tributary flows, excessive sedimentation emanating from tributaries, and the combination of sediment transport and backwater interactions between tributaries and mainstem Klamath. Lower Klamath tributaries such as Terwer and Hunter creeks, begin drying upstream of the mouth and subsurface conditions progress both upstream and downstream of this location as the dry season progresses. Based on YTFP investigations, tributaries that appear most impacted by subsurface flow conditions and that are critically important to Lower Klamath coho salmon include Hunter, Terwer, Ah Pah, Tectah, and Johnsons creeks. Lower Klamath tributaries such as Hunter, Mynot, Hoppaw, Tarup, Omagaar, Bear, and Johnsons creeks were usually the first to begin drying in the spring, and typically experienced periods of subsurface flow during winter and early spring months in the absence of continued, frequent rain events. All of these creeks experienced a disruption or complete cessation of flow during critical juvenile emigration periods for most if not all of the years monitored (Gale and Randolph 2000, Beesley and Fiori 2007b). Because of alterations in the hydrology of tributaries, the timing and magnitude of rains in autumn is crucial for salmonid spawners attempting to gain access to spawning grounds (Voight and Gale 1998), and for juvenile fish seeking refuge in tributary habitats to overwinter (Soto et al. 2008a, Hillemeier et al. 2009).

Impaired Water Quality

Impaired water quality is a moderate stress for this population and is especially detrimental to juveniles, smolts, and adults. The Lower Klamath is listed as impaired for organic enrichment/low dissolved oxygen, sediment/siltation, and water temperature under the Clean Water Act Section 303(d) (NCRWQCB 2008).

Seasonally high water temperatures in the Lower Klamath River, the estuary, and in lower reaches of some LKR tributaries are a limitation for rearing juvenile coho salmon from the LKR and other Klamath Basin populations. Generally, temperatures near the headwaters of LKR tributaries are very good or good, but water quality decreases in the lower reaches (Bjornn and Reiser 1991). Tributaries such as Roaches, Blue, Pine, and Terwer creeks have localized areas of seasonally high water temperature in their lower reaches. YTFP and GDRC have conducted a water temperature monitoring program in Lower Klamath tributaries since 1995 (YTFP 2009b). These efforts have revealed that tributary water temperatures in the Lower Klamath consistently remain within acceptable tolerances for coho salmon (Gale and Randolph 2000, Bell 1991). From 1995 to 2000, the annual variation in average daily water temperature was less than 10 ºC in most Lower Klamath tributaries, with the summer maximum temperature never exceeding 16 ºC in most of these watersheds. Lower Blue Creek had the highest recorded summer water temperatures of all monitored tributaries; however, water temperatures still fell within acceptable tolerances for salmonids throughout the year.

In the Lower Klamath mainstem, maximum water temperatures at three Lower Klamath gauging stations exceeded 24 ºC at times and regularly report temperatures above the critical 22 ºC threshold for most of July and August (Hiner 2006, Beesley and Fiori 2004, 2008b). Temperatures in the estuary have also been recorded as being above lethal thresholds; however, thermal refugia in tidal areas may exist (Wallace 1998, Bartholow 2005). In general, water temperatures in the Lower Klamath mainstem are below 17 ºC in the fall when adults typically migrate upstream, and temperatures do not increase in the spring until most juveniles have outmigrated. However, early adult migrations and late spring and summer juvenile migrations have likely been eliminated as fish are likely forced to leave the mainstem and estuary early, thereby reducing the life history diversity of the population.

Based on current stream and river sedimentation conditions, seasonally high turbidity levels in the Lower Klamath River, and in a majority of its tributaries, are likely a moderate stress to most life stages of coho salmon. Dissolved oxygen (DO) concentrations and pH within the mainstem, estuary, and in some of the off-estuary tributaries are generally adequate but can reach levels which are stressful to coho salmon during late summer. DO concentrations below 7 mg/L have been noted during summer months but are generally above threshold levels during the spring and fall when coho salmon are most abundant in these areas (Hiner and Brown 2004, Hiner 2006, NMFS 2007a, Beesley and Fiori 2004, 2008b). Estuary and mainstem reaches can experience wide diel fluctuations in pH during the summer and have been found to exceed upper thresholds of 8.5 during late summer months. Ammonia toxicity can also be a concern when pH levels are high; however, this is more of a concern in upstream reaches where pH levels are higher (NMFS 2007b).

Adverse Hatchery-Related Effects

No hatcheries or artificial propagation occur in the Lower Klamath population area, but there are two hatcheries in the Klamath River basin. Iron Gate Hatchery is upstream on the Klamath River, and Trinity River Hatchery is on the Trinity River. Hatchery coho salmon were observed during spawning surveys on Blue Creek, a tributary to the Lower Klamath River (Beesley 2010). The proportion of spawning adults in the Lower Klamath River that are of hatchery origin is unknown. Adverse hatchery-related effects pose a medium risk to all life stages, due to the presence of Iron Gate Hatchery and Trinity River Hatchery in the Klamath Basin (Appendix B).

Increased Disease/Predation/Competition

Increased disease, predation, and competition constitute a high stress for most life stages and can have a localized or seasonal impact on both juvenile and adult life stages. Rearing habitat is generally limited in LKR tributaries and competition within these habitats likely results from high seasonal concentrations of juveniles (both natal and non-natal). Off-channel winter habitat and instream summer habitat in upper reaches of tributaries both likely experience density-dependent competition among natal juveniles and between natal and non-natal juveniles. Competition for thermal refugia in mainstem reaches may also be an issue in this population. Some juveniles may rear in the mainstem and estuary and be limited in their distribution due to scarcity of rearing habitat with adequate water quality. Also, adults may need to hold in the mainstem in refugia areas prior to upstream migration due to hydrologic conditions that inhibit access to tributary spawning groups in the Lower Klamath.

Disease is a significant stress to coho salmon in the Lower Klamath River. Diseases that affect adults in the Klamath Basin are primarily from the common pathogens *Ichthyopthirius multifilis* (Ich) and *Flavobacterium columnare* [columnaris; National Research Council (NRC) 2004]. These pathogens were responsible for the 2002 fish kill on the Klamath River (Guillen 2003, CDFG 2004c, Belchik et al. 2004) although adult mortality from Ich and columnaris are not as common as juvenile mortality from *Ceratonova shasta* or *Parvicapsula minibicornis*. Nichols et al. (2003) identified ceratomyxosis, which is caused by *C. shasta*, as the most significant disease for juvenile salmon in the Klamath Basin. Generally, disease exposure is much lower below the Trinity River confluence, but is exacerbated by poor mainstem water quality and stressful conditions in the Lower Klamath River (Bartholomew 2008). Disease effects become most evident as water temperatures rise above 14º C. As with the impacts of poor water quality in the mainstem, some life history strategies may be eliminated due to disease impacts, thereby reducing the viability of the population.

Predation can also have localized impacts, but is generally a natural process unless facilitated by anthropogenic alterations to habitat or predator populations. In the Lower Klamath River, pinniped predation is often speculated to be significant; however, Williamson and Hillemeier (2001) found that pinniped predation rates on coho salmon in 1998 and 1999 were only 0.2

percent and 1.2 percent of returning adult fish, respectively. Pinniped predation rates near shore and in the open ocean may add to this predation. Predation rates on juvenile coho salmon in freshwater may increase seasonally due to inadequate cover and high densities of juveniles in some habitats. Predation rates, while not high, do contribute to a reduction in the number of juveniles that survive and adults returning to the Klamath Basin.

Barriers

Barriers are a medium stress due to the prevalence of flow barriers in most tributaries and the occurrence of road-related barriers. Most tributaries have formed large, persistent gravel deltas at their mouths and these seasonal barriers interrupt successful juvenile emigration in the spring, block adult immigration in the fall, inhibit immigration of non-natal juvenile salmonids, limit the quality and quantity of rearing habitat, increase competition and predation, and alter composition of available food organisms (Payne and Associates 1989, Beesley and Fiori 2007b). There appears to be extensive mortality of juveniles that occurs each year due to subsurface flows, and over-summer survival of natal coho salmon is often reduced by the occurrence of these barriers (Beesley 2010). The dewatering of tributary reaches is primarily the result of excessive aggradation, and loss of fluvial deposited and recruited LWD, as well as altered hydrologic function. Large gravel bars and deltas at the tributary mouths form barriers which require either high tributary or mainstem flows to allow fish passage.

Important road-related fish passage and water conveyance issues have been identified on McGarvey, Waukell, Blue, Terwer, and Richardson creeks. A grade control structure on West Fork McGarvey Creek blocks access to high IP reaches. An undersized culvert on Saugep, Waukell, and Junior creeks; a grade control structure on Waukell Creek (Klamath Beach Road and Hwy 101); and a partially impassible culvert (except at higher Klamath River flows of around 20,000 cfs or higher when backwatering occurs) on Richardson Creek (Klamath Beach Road) block access to important tributary habitat and inhibit geomorphic function and floodplain connectivity and thereby reduce the quality and quantity of rearing habitat (Taylor 2007). The Hwy 169 bridge over Terwer Creek and the GDRC bridge over Blue Creek also inhibit geomorphic function and limit floodplain connectivity in these creeks. Due to the importance of blocked tributary and estuary habitat to the LKR population and other Klamath River populations, providing fish passage at these identified barriers is needed to ensure recovery of SONCC coho salmon.

Adverse Fishery- and Collection-Related Effects

Based on estimates of the fishing exploitation rate, as well as the status of the population relative to depensation and the status of NMFS approval for any scientific collection (Appendix B), these activities pose a medium stress to adults and a low stress to juveniles and smolts.

18.6 Threats

Table 18-7. Severity of threats affecting each life stage of coho salmon in the Lower Klamath River. Threat rank categories, assessment methods, and data used to assess threats are described in Appendix B.

	Threats	Egg	Fry	Juvenile[1]	Smolt	Adult	Overall Threat Rank
1	Agricultural Practices[1]	High	High	Very High[1]	Very High	High	Very High
2	Channelization/Diking[1]	Medium	Medium	Very High[1]	Very High	Medium	Very High
3	Roads	High	High	High	High	High	High
4	Timber Harvest	High	High	High	High	Medium	High
5	Dams/Diversions	Low	Medium	High	High	High	High
6	Climate Change	Low	Low	Medium	Medium	Medium	Medium
7	Hatcheries	Medium	Medium	Medium	Medium	Medium	Medium
8	Urban/Residential/Industrial Dev.	Low	Low	Medium	Medium	Medium	Medium
9	Road-Stream Crossing Barriers	-	Medium	Medium	Low	Low	Medium
10	Invasive Non-Native/Alien Species	Low	Low	Medium	Medium	Low	Medium
11	Mining/Gravel Extraction	Low	Low	Medium	Medium	Low	Medium
12	Fishing and Collecting	-	-	Low	Low	Medium	Low
13	High Severity Fire	Low	Low	Low	Low	Low	Low

[1]Key limiting stresses and limited life stage.

Key Limiting Threats

The two key limiting threats, those which most affect recovery of the population by influencing stresses, are agricultural practices and channelization/diking.

Agricultural Practices

Agricultural practices in the LKR area pose a high to very high threat to coho salmon due to the overlap between agricultural lands and important tributary, mainstem, and estuary habitat. Agriculture in the LKR sub-basin has resulted in the loss of habitat due to draining, diking, or filling of wetland, estuary, and floodplain habitat, the loss of riparian forest and LWD recruitment, and impacts to bank stability and sedimentation. Only a small portion of the Lower Klamath sub-basin is suitable for agriculture but the impacts from agriculture affect some of the most important tributaries and off-estuary habitats for coho salmon, including Salt, Hunter, Mynot, Spruce, Hoppaw, Terwer, Tarup, Panther, and Blue creeks. Portions of the estuary have also been diked and filled for agriculture, especially near the Salt Creek and Hunter Creek confluences and near Rekwoi. The loss of estuarine and tributary habitat is on the order of hundreds of acres of floodplain and wetland habitat (Patterson 2009).

Cattle are actively grazed on private land in Salt, lower Hunter, Mynot, Spruce, Hoppaw, Panther, and lower Terwer creeks. Most of these pastures (except in lower Terwer Creek) are located within the floodplain of the Klamath River. The Hunter, Mynot, Spruce, and Salt Creek pastures were established through diking and conversion of the Hunter Creek slough. The Terwer Creek pastures were established on a large floodplain near the confluence with the Klamath River. Cattle are also grazed on the Klamath River bar at the confluence of Tarup, Pecwan, and Johnsons Creeks. In addition to these established grazing operations, feral cattle exist throughout the Lower Klamath River, particularly in Terwer, Blue, and Bear creeks. Cattle have slowly extended its range over the past 10 years and now extends upstream to the mouth of Slide Creek (Blue Creek tributary), near the lower boundary of the Siskiyou Wilderness Area. Grazing by these feral cattle has degraded riparian function and has created highly unstable banks and high rates of sedimentation and aggradation. Although cattle on Salt, lower Hunter and Mynot creeks have been excluded from the stream channel, cattle operations in these areas remain a significant limitation and threat to coho salmon. In some areas such as Terwer Creek, the YTFP has been working with landowners to provide benefits to both fish habitat and agricultural uses including the construction of two off-channel wetlands and by conversion of hay fields to riparian forests (Fiori et al. 2011a, 2011b, Hiner et al. 2011, Pagliuco et al. 2011, YTFP 2012).

Channelization/Diking

Channelization and diking pose a medium to very high threat to the population due to the associated loss of habitat in the estuary and along many important tributaries. Salt, High Prairie, Hunter, Mynot, Hoppaw, Waukell, Terwer, Saugep, Spruce, and Johnsons creeks have all been impacted by these activities (Gale and Randolph 2000, Beesley and Fiori 2004, 2008b). The lower two miles of Hoppaw Creek have been subjected to levee construction, channel realignment, and channelization for purposes of flood protection and Waukell Creek was realigned and channelized during the relocation of Highway 101 after the 1964 flood. A levee was constructed around the Klamath Glen housing community following the 1964 flood and this levee extends along the lower 0.5 miles of Terwer Creek, between its confluence with the Klamath and the Highway 169 bridge crossing.

Similarly, levee construction has eliminated estuarine slough habitat near the confluence of Salt and Hunter creeks and both these creeks have been channelized through present day pastureland. Hunter Creek levees extend from its mouth to the Hunter Creek subdivision (2.5 miles), while the Salt Creek levees extend upstream of the Requa Road bridge crossing (0.5 miles). High Prairie Creek has been channelized between the Redwood Community subdivision and the Highway 101 bridge crossing (the lower 3,500 feet). Similarly, levees were built along lower Mynot Creek from its confluence with Hunter Creek to upstream of the Margaret Keeting School (Gale and Randolph 2000).

Levees and the channelization associated with them continue to reduce or eliminate hydrologic connectivity of floodplains, wetlands, and estuarine sloughs that provide essential ecosystem functions and productive juvenile rearing areas.

Roads

The density of unpaved roads (>3 mi. per sq. mi) in the Lower Klamath creates a high threat to the coho salmon population. The highest densities of roads (>9.6 mi. per sq. mi) exist in Ah Pah, Surpur, Waukell creeks (Gale and Randolph 2000). Many streams have over 12 road crossings per square mile and the South Fork Ah Pah watershed has over 25 road crossings per square mile (Gale and Randolph 2000). The cumulative sedimentation that has occurred over the past 50 years of road-building and intensive timber harvest has caused significant impacts to stream habitat. GDRC owns and manages approximately 169,600 square miles of lands below the Trinity River confluence for timber production and a majority of roads in the sub-basin exist on these lands. As part of the GDRC HCP (2006), the company has prioritized road upgrades and decommissioning for 30 sub-basins across its Lower Klamath River holdings. Implementation of these measures will contribute to an overall improvement of ecosystem function, habitat quality and quantity through the watersheds with prioritized sites. Although the impacts from some existing roads may decrease through implementation of the HCP, the dominant land use within the Lower Klamath sub-basin is still timber harvest so a majority of these roads will continue to be used and will continue to deliver sediment to streams.

Another major impact from roads is the impact that Highway 101, Highway 169, and rural roads have on estuary and tributary habitat in the Lower Klamath. Highway 101 passes through or borders approximately 3 miles of estuary wetland habitat. In addition to the direct loss caused by the road footprint, the hydrologic connectivity of off-estuary wetlands located in the vicinity of the highway has been altered by the road and associated infrastructure, dikes, and levees along this route (Beesley and Fiori 2008b). This altered hydrology affects estuarine function, especially during storms. Much of the estuary's ability to convey or store high flows without damage to mainstem and tributary channels has been lost. Altered hydrology has also led to downcutting, further separating the streambed from the floodplain. Smaller highways and roads in the sub-basin have a similar effect. For example, the Hwy 169 bridge over Terwer Creek and the GDRC bridge over lower Blue Creek are undersized and limit geomorphic function (Beesley and Fiori 2008a, 2008b). In addition, the Requa Road crossings in lower Salt and Hunter creeks are undersized and the road acts as a levee.

Timber Harvest

Timber harvest is a high threat for a majority of the coho salmon life stages because of the extent of harvest in the Lower Klamath tributaries and the existing poor habitat conditions. The majority of private timber land in the LKR population area is owned by GDRC, and will continue to be harvested for timber. Within GDRC property, harvest occurs at a moderate to high level and under the direction of the company's HCP (GDRC 2006). This plan lays out goals and objectives to minimize and mitigate effects from timber harvest through measures related to road and riparian management, slope stability, and harvesting activities. Timber harvest is still the dominant land use within the Lower Klamath sub-basin and the impacts of these activities, even when carried out under the HCP guidelines, include the reduction of pool habitat, LWD and stream complexity; altered hydrology and nutrient cycling; and increased sediment loads.

Dams/Diversions

Dams and diversions pose a high threat to the majority of coho salmon life stages and have the greatest impact on juveniles, smolts, and adults. Although there are no large dams or major diversions in the Lower Klamath, the large upstream water diversion and the existence of numerous large dams perpetuate impacts on the mainstem Klamath River. Iron Gate, Copco 2 and 1, JC Boyle and Keno dams create significant stresses in the mainstem river (NMFS 2007c, NMFS 2012). Low dissolved oxygen, elevated summer/fall water temperatures, and high nutrients are some of the water quality issues exacerbated by the five mainstem dams. Poor water quality and changes in hydrology in the mainstem has been shown to affect disease incidence and mortality as well.

There are only a few diversions in the LKR sub-basin, and are assumed minor relative to available water supply. Diversions to the Klamath Project and non-Project users in the Upper Klamath sub-basin, the Trinity River Diversion, and diversions from the Scott and Shasta Rivers, decrease the total volume of water that otherwise would have naturally flowed down the Lower Klamath River reach (NMFS 2009a, NMFS and USFWS 2013). The Klamath Project diverts between approximately 245,000 to 350,000 acre-feet (depending on water year type) each year. The Trinity River Division diverts an average of 53 percent (670,393 AF) of the sub-basin runoff at Lewiston. Together, these major diversions cumulatively decrease the natural mainstem flows of the Lower Klamath River by an average of 915,000 to 1,020,000 acre-feet per year. Reductions in flow and changes in the shape of the hydrograph can exacerbate water quality issues in the mainstem and increase the occurrence and severity of sediment barriers at many tributary mouths in the Lower Klamath. These diversions decrease the quantity of mainstem flows on the Klamath River mostly during the spring and summer months, when juvenile access to cooler tributaries and cooler mainstem water temperatures is essential.

Generally, spring and summer flows are lower than historic conditions, while fall and winter flows in the Lower Klamath are generally similar to those in the past.

Climate Change

Climate change poses a medium threat to this population. The impacts of climate change in this region will have the greatest impact on juveniles, smolts, and adults. Although the current climate is generally cool, modeled regional average temperature show a moderate increase over the next 50 years. Average temperatures could increase by up to 1.8 °C in the summer and by 1 °C in the winter. Recent studies have already shown that water temperatures in the Lower Klamath mainstem have already been increasing at a rate of 0.4 °C/decade since the early 1960s (Bartholow 2005). The season of high temperatures that are potentially stressful to salmon has lengthened by about 1 month (Bartholow 2005). Snowpack in the Klamath Basin will likely decrease with changes in temperature and precipitation and these changes will likely impact mainstem and tributary hydrology (California Natural Resources Agency [CNRA] 2009).

The vulnerability of the estuary and coast to changes in sea level is moderate in this region due to projected sea level rise and local rates of subsidence. Juvenile and smolt rearing and migratory habitat are most at risk to climate change as is adult access to tributary spawning habitat. Increasing temperatures and changes in the amount and timing of precipitation and snowmelt will impact water quality and hydrologic function and could impact the duration of barriers at the mouths of tributaries. Factors such as the timing, intensity, and extent of rainfall could either improve accessibility to tributaries or make it more difficult for fish to immigrate and emigrate from tributaries. Rising sea level may also impact the quality and extent of wetland rearing habitat in the estuary. Wetlands would naturally migrate inland with rising sea level but there are few places that are unarmored and would allow for this migration. Overall, the range and degree of variability in temperature and precipitation are likely to increase in all populations. Adults will also be negatively impacted by changes in ocean conditions, such as ocean acidification, and prey availability (Independent Science Advisory Board 2007, Portner and Knust 2007, Feely et al. 2008).

Hatcheries

Hatcheries pose a medium threat to all life stages in the Lower Klamath River sub-basin. The rationale for these ratings is described under the “Adverse Hatchery-Related Effects” stress.

Urban/Residential/Industrial Development

Currently, urbanization is an overall medium threat. The effects of population growth and related development are localized within the LKR population area. The principal population areas near fish-bearing tributaries are Requa, Klamath, and Klamath Glen in the lower portion of the sub-basin, and Wautek (Johnsons) and Pecwan in the upper portion. Activities in the Lower Klamath associated with development include levee construction, water withdrawal, bank armoring, and vegetation removal. The increased use of off-highway vehicles in and next to Lower Klamath tributaries is also associated with development. The tributaries most impacted include Salt, High Prairie, Hunter, Mynot, Hoppaw, Waukell, and Terwer creeks. Land development in the Lower Klamath often results in the loss and degradation of critical floodplain and wetland habitat, especially in the vicinity of the estuary. The existing towns of Klamath, Klamath Glen, and Requa will continue to grow, though slowly. As these towns continue to expand, more infrastructure will likely be needed to protect private property and floodplains will likely be developed to accommodate more growth. This usually results in more levee construction, more roads, and resultant loss of fisheries habitats. In addition, sewage, pollution, water diversions, and removal of riparian vegetation could increase.

Fishing and Collecting

Based on estimates of the fishing exploitation rate, as well as the status of the population relative to depensation and the status of NMFS approval for any scientific collection (Appendix B), these activities pose a medium threat to adults and a low stress to juveniles and smolts.

Road-Stream Crossing Barriers

Road-stream crossing barriers are a low to medium threat due to the occurrence of several fish passage barriers (Taylor 2007, CalFish 2009). Possible affected streams include McGarvey, Richardson, Saugep, Waukell, Junior Creek, Blue, and Terwer creeks and a Highway 101 grade control structure barrier on West Fork McGarvey Creek blocks access to high IP reaches.

Another impassable highway grade control structure exists on Waukell Creek, and an undersized culvert exists on Richardson Creek that is impassable most of the time except when backwatering occurs from the mainstem Klamath River at higher flows. Several road crossings in the vicinity of the estuary (e.g., Saugep, Junior, and Spruce creeks) have limited passage for coho salmon (Taylor 2007). Several other total barriers exist in the sub-basin, but are on streams where coho salmon have not been documented and no IP exists (e.g., Burrill, Rube, Mareep, Knulthkarn). The culverts on Waukell and Junior creeks are likely to be addressed in the next few years.

Table 18-8. List of road-stream crossing barriers in the Lower Klamath River population area.

Priority	Stream Name	Barrier Type	Road Name	Barrier	Miles of habitat upstream of barrier
High	Salt Creek	Culvert	Requa Road	Partial	>1
High	Richardson Creek	Culvert	Klamath Beach Rd	Partial	1
High	Junior	Culvert	Unnamed	Partial	>1
Medium	Saugep	Culvert	Klamath	Partial	>1
Medium	Spruce	Culvert	Hwy 101	Partial	>1
Medium	Salt	Culvert	GDRC Road	Partial	<1
Low	Waukell Creek	Grade Control Structure	Hwy 101	Complete	>1
Low	Waukell Creek	Culvert	Hwy 101	Partial	<1
Low	McGarvey Creek	Grade Control Structure	Hwy 101	Complete	<1

Invasive Non-Native/Alien Species

A few non-native invasive species may be affecting this population, having a low to medium effect on coho salmon life stages in the population. Bullfrog, bass, sunfish, and brown trout predation potentially have an effect on juvenile coho salmon in certain areas of the LKR population area. In addition to predation, some tributaries in the vicinity of the estuary (e.g., Junior, Waukell, Salt, and Spruce creeks) are currently overgrown with non-native invasive plant species which impact water quality, inhibit the establishment of native riparian species, and dramatically reduce rearing capacity (Taylor 2007). The most prevalent invasive species are reed canary grass (*Phalaris arundinacea*), Himalayan blackberry (*Rubus procerns, Rubus discolor*), common reed (*Phragmites australis*), and the yellow pond lily (*Nuphar lutea*) (Patterson 2009, YTFP 2009b).

Mining/Gravel Extraction

Gravel extraction poses a medium threat to juvenile and smolt coho salmon and a low threat to the other life stages. In the LKR tributaries, there has been only one commercial gravel mining operation, which has extracted 5,000 to 15,000 cubic yards of gravel each year from different locations in lower Hunter Creek during late summer and early fall. Gravel extraction on the LKR mainstem has been limited overall, but mining on mainstem gravel bars and on lower

Terwer Creek has been proposed (McBride 1990). Gravel extraction has also been proposed to address the delta barriers at the mouths of Lower Klamath tributaries, but no such activities have occurred yet. This would not be a long-term solution to the issue, but the gravel operations on the lower Van Duzen River is a good example of how gravel mining can improve fish passage if done correctly. If not managed or designed properly, gravel extractions could disturb juveniles and degrade instream and riparian habitats.

High Severity Fire

The threat of high severity fire in the Lower Klamath is low because climatic conditions do not favor frequent or high-intensity fires in this area. What fire risks do exist in this area are the result of past timber harvest activities, fire suppression, and climate change.

18.7 Recovery Strategy

Although the Lower Klamath River population is currently depressed in abundance and habitat is degraded in most areas, the potential for coho salmon recovery is very high. Based on what is known about habitat availability and quality, spawning habitat and summer and winter rearing habitat appear to be limited by sediment loading and a lack of floodplain and channel structure. Currently, a few key tributaries support the majority of coho salmon production and provide refugia for the population. These and other important tributaries would benefit from strategic restoration actions targeted at reducing upslope sources of sediment, improving riparian function, and enhancing stream habitat complexity and floodplain connectivity.

Restoring or enhancing floodplain and channel structure is particularly important and can be accomplished by placing complex wood jams and/or engineered log jams throughout Lower Klamath tributaries, and critical mainstem and estuary habitats. Constructing these complex and/or engineered log jams, along with other wood loading activities, will facilitate retention of recruited wood, form pools, and connect creeks to their floodplain, promote development of productive and resilient riparian forests, and sort and meter sediment in ways that support vital processes, such as formation and retention of high quality salmonid spawning gravels and storage of fine-grained materials on floodplains. In addition, constructing off-channel habitats, wetlands, and side-channels, removing or setting back levees, decreasing sediment input, and stabilizing uplands are also high priority recovery actions. The immediate restoration and maintenance of LKR tributary riparian forests, hydrologic function, and floodplain and channel structure for spawning and rearing will help increase productivity, abundance, and distribution of the population.

Recovery actions aimed at improving mainstem water quality, tributary access, and estuary habitat will benefit not only the LKR population, but also upstream Klamath River populations that use the LKR sub-basin for non-natal rearing and as migratory habitat. In addition, constructing off-channel ponds, wetlands, and side-channels, removing or setting back levees, decreasing sediment input, and stabilizing uplands are also high priority recovery actions. These restoration efforts can be complemented by providing for the enhancement of beaver populations and the creation of beaver analogue structures in suitable low-gradient habitat. The removal of four mainstem dams in the Upper Klamath as provided in the Klamath Hydroelectric Settlement

Agreement is also important to the improvement of hydrologic function, water quality, and disease conditions in the mainstem Klamath and estuary.

To improve the viability of this population, addressing these limiting stresses and to improve habitat conditions for these life stages throughout the sub-basin will be imperative. Addressing other stresses and threats and improving habitat for all life stages and life history strategies will also be an important component of recovery for this population. For fish from the population that have a life history that depends on the estuary and mainstem river (and for non-natal populations), creating and enhancing complex off-channel slough and wetland habitat and restoring connectivity to this habitat is imperative. Mainstem habitats should also be enhanced to improve overwinter rearing conditions for all life stages and species. The effects of fishing on this population's ability to meet its viability criteria should be evaluated.

Table 18-9 on the following page lists the recovery actions for the Lower Klamath River population.

Table 18-9. Recovery action implementation schedule for the Lower Klamath River population. Recovery actions for monitoring and research are listed in tables at the end of Chapter 5.

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-LKR.2.2.8	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Remove, set back, or reconfigure levees and dikes	Mainstem Klamath River, Klamath River Estuary, Terwer, Klamath Glen, Salt, High Prairie, Hunter, Mynot, Hoppaw, Waukell	1
SONCC-LKR.2.2.8.1	*Assess feasibility and develop a plan to remove or set back levees and dikes that includes restoring the natural channel form and floodplain connectivity once the levees and dikes have been removed or set back*					
SONCC-LKR.2.2.8.2	*Remove or setback levees and dikes and restore channel form and floodplain connectivity, guided by the plan*					
SONCC-LKR.1.2.39	Estuary	No	Improve estuarine habitat	Assess and improve estuary and tidal wetland habitat	Estuary	1
SONCC-LKR.1.2.39.1	*Identify parameters to assess condition of estuary and tidal wetland habitat*					
SONCC-LKR.1.2.39.2	*Determine amount of estuary and tidal wetland habitat needed for population recovery and develop a plan for restoration*					
SONCC-LKR.1.2.39.3	*Restore estuary and tidal wetland habitat guided by the plan*					
SONCC-LKR.2.1.1	Floodplain and Channel Structure	Yes	Increase channel complexity	Increase LWD, boulders, or other instream structure	Mainstem Klamath River, Estuary, lower Klamath River tributaries, and all streams where coho salmon would benefit immediately	2a
SONCC-LKR.2.1.1.1	*Assess habitat to determine beneficial location and amount of instream structure needed*					
SONCC-LKR.2.1.1.2	*Place instream structures, guided by assessment results*					
SONCC-LKR.2.1.60	Floodplain and Channel Structure	Yes	Increase channel complexity	Increase LWD, boulders, or other instream structure	Population wide	2b
SONCC-LKR.2.1.60.1	*Assess habitat to determine beneficial location and amount of instream structure needed*					
SONCC-LKR.2.1.60.2	*Place instream structures, guided by assessment results*					
SONCC-LKR.2.2.2	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Construct off channel habitats, alcoves, backwater habitat, and old stream oxbows	Mainstem Klamath River, Estuary, lower Klamath River tributaries, and all streams where coho salmon would benefit immediately	2a
SONCC-LKR.2.2.2.1	*Identify potential sites to create refugia habitats. Prioritize sites and determine best means to create rearing habitat*					
SONCC-LKR.2.2.2.2	*Implement restoration projects that improve off channel habitats to create refugia habitat, as guided by assessment results*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-LKR.2.2.61	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Construct off channel habitats, alcoves, backwater habitat, and old stream oxbows	Population wide	2b
SONCC-LKR.2.2.61.1	*Identify potential sites to create refugia habitats. Prioritize sites and determine best means to create rearing habitat*					
SONCC-LKR.2.2.61.2	*Implement restoration projects that improve off channel habitats to create refugia habitat, as guided by assessment results*					
SONCC-LKR.2.2.6	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Increase beaver abundance	Mainstem Klamath River, Estuary, and lower Klamath River tributaries, and all streams where coho salmon would benefit immediately	2a
SONCC-LKR.2.2.6.1	*Develop a beaver conservation plan that includes education and outreach, technical assistance for land owners, and methods for reintroduction and/or relocation of beaver as a last resort*					
SONCC-LKR.2.2.6.2	*Implement education and technical assistance programs for landowners, guided by the plan*					
SONCC-LKR.2.2.6.3	*Reintroduce or relocate beaver if appropriate, guided by the plan*					
SONCC-LKR.2.2.63	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Increase beaver abundance	Population wide	2b
SONCC-LKR.2.2.63.1	*Develop a beaver conservation plan that includes education and outreach, technical assistance for land owners, and methods for reintroduction and/or relocation of beaver as a last resort*					
SONCC-LKR.2.2.63.2	*Implement education and technical assistance programs for landowners, guided by the plan*					
SONCC-LKR.2.2.63.3	*Reintroduce or relocate beaver if appropriate, guided by the plan*					
SONCC-LKR.2.2.4	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Re-connect existing off-channel ponds, wetlands, and side channels	Mainstem Klamath River, Estuary, and lower Klamath River tributaries, and all streams where coho salmon would benefit immediately	2a
SONCC-LKR.2.2.4.1	*Assess instream flow conditions and side channel connectivity and develop a plan to obtain adequate flows for channel connectivity*					
SONCC-LKR.2.2.4.2	*Mechanically alter or install constructed wood jams or engineered wood jams in side channels, off channel ponds, and wetlands to achieve and maintain connectivity*					
SONCC-LKR.2.2.4.3	*Install flow gage to ensure appropriate flows*					
SONCC-LKR.2.2.62	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Re-connect existing off-channel ponds, wetlands, and side channels	Population wide	2b
SONCC-LKR.2.2.62.1	*Assess instream flow conditions and side channel connectivity and develop a plan to obtain adequate flows for channel connectivity*					
SONCC-LKR.2.2.62.2	*Mechanically alter or install constructed wood jams or engineered wood jams in side channels, off channel ponds, and wetlands to achieve and maintain connectivity*					
SONCC-LKR.2.2.62.3	*Install flow gage to ensure appropriate flows*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-LKR.8.1.11	Sediment	Yes	Reduce delivery of sediment to streams	Reduce road-stream hydrologic connection	All Lower Klamath River Tributaries (especially Waukell, Ah Pah, Surpur, Blue, McGarvey, Hoppaw, Mynot, Hunter, Terwer, Tarup) and all areas where coho salmon would benefit immediately	2a
SONCC-LKR.8.1.11.1	*Assess and prioritize road-stream connection, and identify appropriate treatments*					
SONCC-LKR.8.1.11.2	*Decommission roads, guided by assessment*					
SONCC-LKR.8.1.11.3	*Upgrade roads, guided by assessment*					
SONCC-LKR.8.1.11.4	*Maintain roads, guided by assessment*					
SONCC-LKR.8.1.68	Sediment	Yes	Reduce delivery of sediment to streams	Reduce road-stream hydrologic connection	Population wide	2b
SONCC-LKR.8.1.68.1	*Assess and prioritize road-stream connection, and identify appropriate treatments*					
SONCC-LKR.8.1.68.2	*Decommission roads, guided by assessment*					
SONCC-LKR.8.1.68.3	*Upgrade roads, guided by assessment*					
SONCC-LKR.8.1.68.4	*Maintain roads, guided by assessment*					
SONCC-LKR.7.1.14	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Increase conifer riparian vegetation	Blue, Hunter, Hoppaw, Terwer, McGarvey, Tarup, Omagaar, Ah Pah, Bear, Surpur, Little Surpur, Tully, Waukell, Saugep, Tectah	2b
SONCC-LKR.7.1.14.1	*Develop an appropriate timber harvest management plan for benefits to coho salmon habitat*					
SONCC-LKR.7.1.14.2	*Thin, or release conifers, guided by the plan*					
SONCC-LKR.7.1.14.3	*Plant conifers, guided by the plan*					
SONCC-LKR.3.1.57	Hydrology	No	Improve flow timing or volume	Increase instream flows	All streams where coho salmon would benefit immediately	2c
SONCC-LKR.3.1.57.1	*Identify diversions in tributaries that have subsurface or low flow barrier conditions during the summer*					
SONCC-LKR.3.1.57.2	*Reduce diversions using a combination of incentives and enforcement measures*					
SONCC-LKR.3.1.64	Hydrology	No	Improve flow timing or volume	Increase instream flows	Population wide	2d
SONCC-LKR.3.1.64.1	*Identify diversions in tributaries that have subsurface or low flow barrier conditions during the summer*					
SONCC-LKR.3.1.64.2	*Reduce diversions using a combination of incentives and enforcement measures*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-LKR.8.1.9	Sediment	Yes	Reduce delivery of sediment to streams	Quantify dominant sediment sources and sinks	All areas where coho salmon would benefit immediately	3c
SONCC-LKR.8.1.9.1	*Complete sediment budget*					
SONCC-LKR.8.1.70	Sediment	Yes	Reduce delivery of sediment to streams	Quantify dominant sediment sources and sinks	Population wide	2d
SONCC-LKR.8.1.70.1	*Complete sediment budget*					
SONCC-LKR.7.1.16	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Revegetate riparian areas	Population wide	2d
SONCC-LKR.7.1.16.1	*Control feral cattle to rehabilitate riparian forests*					
SONCC-LKR.8.1.13	Sediment	Yes	Reduce delivery of sediment to streams	Reduce stream bank erosion	All Lower Klamath Tributaries (especially Blue, Waukell, Ah Pah, Terwer, Hunter, Hoppaw, Tarup, Omagaar), all areas where coho salmon would benefit immediately	3a
SONCC-LKR.8.1.13.1	*Inventory sediment sources, and prioritize for treatment*					
SONCC-LKR.8.1.13.2	*Treat priority sediment source sites, guided by assessment*					
SONCC-LKR.8.1.69	Sediment	Yes	Reduce delivery of sediment to streams	Reduce stream bank erosion	Population wide	3b
SONCC-LKR.8.1.69.1	*Inventory sediment sources, and prioritize for treatment*					
SONCC-LKR.8.1.69.2	*Treat priority sediment source sites, guided by assessment*					
SONCC-LKR.2.2.3	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Revise restoration plan	Mainstem Klamath River, Estuary, and lower Klamath River tributaries	3b
SONCC-LKR.2.2.3.1	*Revise the Yurok Tribe's Lower Klamath Sub-basin Restoration Plan to include updated prioritized, site specific restoration treatments for 1) Lower Klamath tributaries; 2) mainstem river habitats; and 3) the Klamath River estuary and off-estuary slough and wetland habitats*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-LKR.5.1.40	Passage	No	Improve access	Remove barriers	All streams where coho salmon would benefit immediately	3b
SONCC-LKR.5.1.40.1	*Evaluate and prioritize barriers for removal*					
SONCC-LKR.5.1.40.2	*Remove barriers, guided by the assessment*					
SONCC-LKR.5.1.65	Passage	No	Improve access	Remove barriers	Population wide	3c
SONCC-LKR.5.1.65.1	*Evaluate and prioritize barriers for removal*					
SONCC-LKR.5.1.65.2	*Remove barriers, guided by the assessment*					
SONCC-LKR.3.1.55	Hydrology	No	Improve flow timing or volume	Increase instream flows	Population wide	3b
SONCC-LKR.3.1.55.1	*Identify and cease unauthorized water diversions*					
SONCC-LKR.3.1.58	Hydrology	No	Improve flow timing or volume	Provide adequate instream flow for coho salmon	Population wide	3b
SONCC-LKR.3.1.58.1	*Conduct study to determine instream flow needs of coho salmon at all life stages.*					
SONCC-LKR.3.1.58.2	*If coho salmon instream flow needs are not being met, develop plan to provide adequate flows. Plan may include water conservation incentives for landowners and re-assessment of water allocation.*					
SONCC-LKR.3.1.58.3	*Implement coho salmon instream flow needs plan.*					
SONCC-LKR.7.1.15	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve grazing practices	Mainstem Klamath River, Klamath River Estuary, Lower Klamath River tributaries (especially Salt, Hunter, Blue, Terwer Creeks), all areas where coho salmon would benefit immediately	3b
SONCC-LKR.7.1.15.1	*Assess grazing impact on sediment delivery and riparian condition, identifying opportunities for improvement*					
SONCC-LKR.7.1.15.2	*Develop grazing management plans to improve water quality and coho salmon habitat*					
SONCC-LKR.7.1.15.3	*Plant vegetation to stabilize stream bank*					
SONCC-LKR.7.1.15.4	*Fence livestock out of riparian zones*					
SONCC-LKR.7.1.15.5	*Remove instream livestock watering sources*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-LKR.7.1.66	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve grazing practices	Population wide	3d
SONCC-LKR.7.1.66.1	*Assess grazing impact on sediment delivery and riparian condition, identifying opportunities for improvement*					
SONCC-LKR.7.1.66.2	*Develop grazing management plans to improve water quality and coho salmon habitat*					
SONCC-LKR.7.1.66.3	*Plant vegetation to stabilize stream bank*					
SONCC-LKR.7.1.66.4	*Fence livestock out of riparian zones*					
SONCC-LKR.7.1.66.5	*Remove instream livestock watering sources*					
SONCC-LKR.7.1.54	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Remove reed canary grass in coho salmon habitat	All streams where coho salmon would benefit immediately	3b
SONCC-LKR.7.1.54.1	*Determine appropriate methods to remove reed canary grass in coho salmon habitat*					
SONCC-LKR.7.1.54.2	*Remove reed canary grass in coho salmon habitat*					
SONCC-LKR.7.1.67	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Remove reed canary grass in coho salmon habitat	Population wide	3d
SONCC-LKR.7.1.67.1	*Determine appropriate methods to remove reed canary grass in coho salmon habitat*					
SONCC-LKR.7.1.67.2	*Remove reed canary grass in coho salmon habitat*					
SONCC-LKR.26.1.56	Low Population Dynamics	No	Increase population abundance	Rescue and relocate stranded juveniles	Population wide	3b
SONCC-LKR.26.1.56.1	*Survey coho-bearing tributaries and relocate juveniles stranded in drying pools*					
SONCC-LKR.10.7.53	Water Quality	No	Restore nutrients	Add marine-derived nutrients to streams	All streams where coho salmon would benefit immediately	3c
SONCC-LKR.10.7.53.1	*Develop a plan to supply appropriate amounts of marine-derived nutrients to streams (e.g. carcass placement, pellet dispersal)*					
SONCC-LKR.10.7.53.2	*Supply marine-derived nutrients to streams guided by the plan*					
SONCC-LKR.10.7.59	Water Quality	No	Restore nutrients	Add marine-derived nutrients to streams	Population wide	3d
SONCC-LKR.10.7.59.1	*Develop a plan to supply appropriate amounts of marine-derived nutrients to streams (e.g. carcass placement, pellet dispersal)*					
SONCC-LKR.10.7.59.2	*Supply marine-derived nutrients to streams guided by the plan*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID		*Step Description*				
SONCC-LKR.8.1.12	Sediment	Yes	Reduce delivery of sediment to streams	Improve regulatory mechanisms	Population wide	3d
SONCC-LKR.8.1.12.1	*Develop grading ordinance for maintenance and building of private roads that minimizes the effects to coho*					
SONCC-LKR.8.1.10	Sediment	Yes	Reduce delivery of sediment to streams	Reduce erosion	Population wide	3d
SONCC-LKR.8.1.10.1	*Identify and prioritize upslope sources with excessive sediment loads, and design treatments*					
SONCC-LKR.8.1.10.2	*Implement sediment treatments, guided by assessment results*					
SONCC-LKR.3.1.20	Hydrology	No	Improve flow timing or volume	Educate stakeholders	Population wide	3d
SONCC-LKR.3.1.20.1	*Develop an educational program about water conservation programs and instream leasing programs*					
SONCC-LKR.3.1.21	Hydrology	No	Improve flow timing or volume	Improve regulatory mechanisms	Population wide	3d
SONCC-LKR.3.1.21.1	*Work with partners to streamline the process needed for the dedication of water to fish and wildlife resources under CA Water Code section 1707*					
SONCC-LKR.3.1.21.2	*Implement water dedications to increase instream flows using the streamlined process*					
SONCC-LKR.3.1.22	Hydrology	No	Improve flow timing or volume	Improve regulatory mechanisms	Population wide	3d
SONCC-LKR.3.1.22.1	*Establish a categorical exemption under CEQA for water leasing to increase instream flows*					
SONCC-LKR.3.1.23	Hydrology	No	Improve flow timing or volume	Improve regulatory mechanisms	Population wide	3d
SONCC-LKR.3.1.23.1	*Establish a comprehensive groundwater permit process*					
SONCC-LKR.7.1.18	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve timber harvest practices	Population wide	3d
SONCC-LKR.7.1.18.1	*Amend California Forest Practice Rules to include regulations which describe the specific analysis, protective measures, and procedure required by timber owners and CalFire to demonstrate timber operations described in timber harvest plans meet the requirements specified in 14 CCR 898.2(d) prior to approval by the Director (similar to a Spotted Owl Resource Plan)*					
SONCC-LKR.16.1.25	Fishing/Collecting	No	Manage fisheries consistent with recovery of SONCC coho salmon	Incorporate SONCC coho salmon VSP delisting criteria when formulating salmonid fishery management plans affecting SONCC coho salmon	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3d
SONCC-LKR.16.1.25.1	*Determine impacts of fisheries management on SONCC coho salmon in terms of VSP parameters*					
SONCC-LKR.16.1.25.2	*Identify level of fishing impacts that does not limit attainment of population-specific viability criteria*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-LKR.16.1.51	Fishing/Collecting	No	Manage fisheries consistent with recovery of SONCC coho salmon	Incorporate SONCC coho salmon VSP delisting criteria when formulating salmonid fishery management plans affecting SONCC coho salmon	Tribal lands	3d
SONCC-LKR.16.1.51.1	*Determine impacts of fisheries management on SONCC coho salmon in terms of VSP parameters*					
SONCC-LKR.16.1.51.2	*Identify level of fishing impacts that does not limit attainment of population-specific viability criteria*					
SONCC-LKR.16.1.26	Fishing/Collecting	No	Manage fisheries consistent with recovery of SONCC coho salmon	Reduce fishing impacts to levels that do not limit recovery	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3d
SONCC-LKR.16.1.26.1	*Determine actual fishing impacts*					
SONCC-LKR.16.1.26.2	*If actual fishing impacts limit attainment of population-specific viability criteria, modify management so that fishing does not limit attainment of population-specific viability criteria*					
SONCC-LKR.16.1.52	Fishing/Collecting	No	Manage fisheries consistent with recovery of SONCC coho salmon	Reduce fishing impacts to levels that do not limit recovery	Tribal lands	3d
SONCC-LKR.16.1.52.1	*Determine actual fishing impacts*					
SONCC-LKR.16.1.52.2	*If actual fishing impacts limit attainment of population-specific viability criteria, modify management so that fishing does not limit attainment of population-specific viability criteria*					
SONCC-LKR.16.2.27	Fishing/Collecting	No	Manage scientific collection consistent with recovery of SONCC coho salmon	Incorporate SONCC coho salmon VSP delisting criteria when formulating scientific collection authorizations affecting SONCC coho salmon	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3d
SONCC-LKR.16.2.27.1	*Determine impacts of scientific collection on SONCC coho salmon in terms of VSP parameters*					
SONCC-LKR.16.2.27.2	*Identify level of scientific collection impact that does not limit attainment of population-specific viability criteria*					
SONCC-LKR.16.2.28	Fishing/Collecting	No	Manage scientific collection consistent with recovery of SONCC coho salmon	Reduce impacts of scientific collection to levels that do not limit recovery	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3d
SONCC-LKR.16.2.28.1	*Determine actual impacts of scientific collection*					
SONCC-LKR.16.2.28.2	*If actual scientific collection impacts limit attainment of population-specific viability criteria, modify collection so that impacts do not limit attainment of population-specific viability criteria*					

Action ID	Target	KLS/T	Strategy	Action Description	Area	Priority
Step ID	*Step Description*					
SONCC-LKR.10.2.45	Water Quality	No	Reduce pollutants	Reduce pesticides	Population wide	3d
SONCC-LKR.10.2.45.1	*Develop a pesticide management plan*					
SONCC-LKR.10.2.45.2	*Implement pesticide management plan and technical assistance program*					
SONCC-LKR.2.2.7	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Improve regulatory mechanisms	Population wide	BR
SONCC-LKR.2.2.7.1	*Improve protective regulations for beaver and develop guidelines for relocation that are practical for restoration groups*					
SONCC-LKR.7.1.17	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Reduce the risk of catastrophic fires on riparian forests by allowing for natural fire regime by creating fire-safe private lands	All Lower Klamath River Tributaries (e.g. Blue, Ah Pah, Terwer, Hunter, Tectah, Surpur, Mettah, Pecwan, Bear)	BR
SONCC-LKR.7.1.17.1	*Develop educational materials for landowners in the urban/rural interface areas and for USFS distribution*					
SONCC-LKR.7.1.17.2	*Develop a plan for fire break stewardship and defensible space*					
SONCC-LKR.7.1.17.3	*Implement fire-safe community action plans in identified areas*					

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