18. Lower Klamath River Population

- Central Coastal Stratum
- Core, Functionally Independent Population
- High Extinction Risk
- 5,900 Spawners Required for ESU Viability
- 492.3 mi^2
- 205 IP-km (127 mi) (28 % High)
- Dominant Land Use is Timber Harvest
- Principal Stresses are 'Altered Sediment Supply' and Lack of Floodplain and Channel Structure'
- Principal Threats are 'Roads' and 'Timber Harvest'

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) subbasin. Small-scale commercial harvest began in the mid- to late-1890s, while intensive logging began in the 1950s with a peak harvest in the late 1960s. By 1969, approximately 50 percent of the subbasin 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 subbasin 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 and by 1994 the road density in the subbasin 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). Today, Green Diamond Resource Company (GDRC, formerly Simpson Timber Company) conducts the majority of timber harvest in the subbasin and operates under a Habitat Conservation Plan (GDRC 2006).

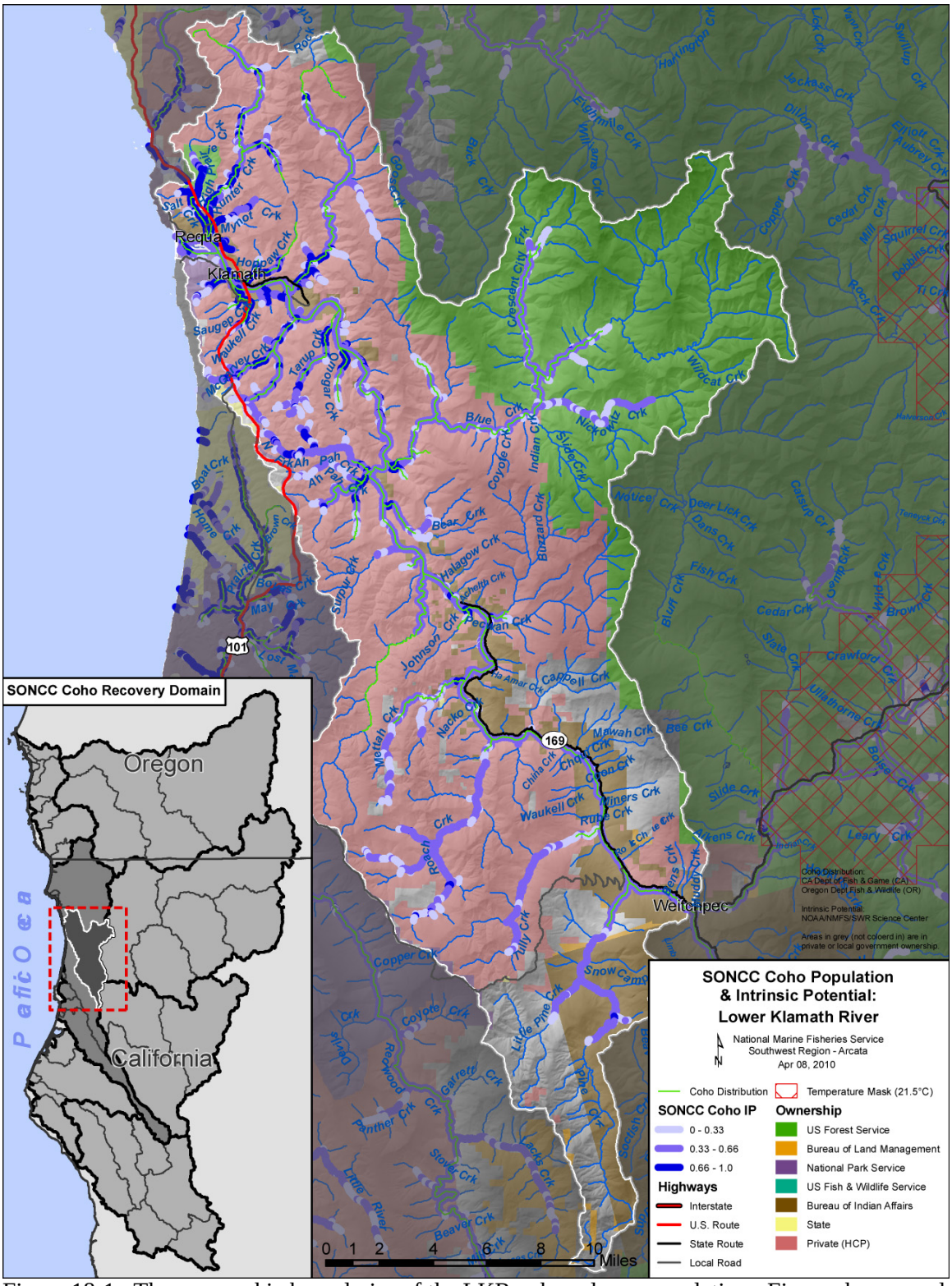

Figure 18-1. The geographic boundaries of the LKR coho salmon population. Figure shows modeled Intrinsic Potential of habitat (Williams et al. 2006), land ownership, coho salmon distribution (CDFG 2009a), and location within the Southern-Oregon/Northern California Coast Coho Salmon ESU and the Northern Coastal diversity stratum (Williams et al. 2006). Grey areas indicate private ownership.

Other activities have also played a role in the subbasin history with rural residential development occurring concurrently with the timber harvest. The principal human population centers, near fish-bearing tributaries, include Requa, Klamath and Klamath Glen in the lower portion of the subbasin, and Wautek (Johnsons) and Pecwan in the upper portion of the subbasin. Although only a small portion of the subbasin 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, and construction of the Highway 101 bypass further reduced floodplain habitat. Small-scale gravel mining and water diversions have also have 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 subsequent loss of LWD (Payne and Associates 1989, Gale and Randolph 2000).

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 Game (CDFG 2004b) 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). The percentage of these fish that originated from the LKR coho salmon population is also unknown.

Historical CDFG 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 Roach 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 CDFG. Although most of these plantings were of fish originating from within the subbasin, 20,000 out-of-basin coho salmon from Alsea River, Oregon, were planted in McGarvey Creek between 1962 to 1963. 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 subbasins 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 LKR subbasin tributaries. (Data from Voight and Gale 1998).

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

Data concerning historic fish rescue in LKR tributaries provide some information about the abundance of coho salmon in the population area. For example, from 1939 to 1945 there were between 152 and 25,226 juvenile coho salmon rescued in Hunter Creek, from 1950 to 1952 there were between 380 and 3,537 coho salmon juveniles rescued in High Prairie Creek, and in 1940 there were 10,000 juvenile coho salmon rescued in Mynot Creek (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, Roach and Ah Pah creeks, but there were less than 10 individuals per creek (Brown and Moyle 1991).

Williams et al. (2008) concluded, based on the model results to predict the IP coho salmon habitat, that the amount of 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 instances of 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
W. Fork McGarvey Creek	Waukell Creek	Johnson Creek
Terwer Creek	Saugep Creek	Hog Ranch Creek
Hoppaw Creek	Junior Creek	Roach 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 reliable records appear to exist on the production of coho salmon in this population, but it is probably high (Brown and Moyle 1991, Soto et al. 2008, Hillemeier et al. 2009, Silloway 2010).

18.3 Status of Lower Klamath River Coho Salmon

Spatial Structure and Diversity

The Yurok Tribe, CDFG, and GDRC conducted multiple fish surveys over the past several decades and from these data we can assess, to some degree, the spatial structure of the LKR coho salmon population. Surveys conducted between 1996 and 2004 found coho salmon in nearly all surveyed streams including Salt Creek, High Prairie, Hunter, Hoppaw, Saugep, Waukell, Terwer, McGarvey, Tarup, Omagaar, Blue, Ah Pah, Bear, Surpur, Little Surpur, , Pularvasar, One Mile, Tectah, Johnsons, Pecwan, Mettah, Roach, Cappell, 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 habitat (e.g., Mettah, Roach, 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 attributable to non-natal rearing [Voight and Gale 1998, Yurok Tribal Fisheries Program (YTFP) 2009b].

When present, coho salmon were generally scarce and confined to the lower reaches of tributaries. However, surveys in 1996 indicated well-distributed coho salmon in McGarvey and Blue creeks, with observed patterns similar to historical reports. 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 young-of-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, 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 less notable during subsequent years.

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 may provide more accurate information regarding natal population distribution. Spawning data from a few of the major tributaries in the LKR shows 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 subbasin. 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 LKR population with recent coho salmon presence. Based on surveys by CDFG and YTFP 1990 to 2008.

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

For the LKR coho salmon population to be at low risk for the spatial structure and diversity 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. Coho salmon are well distributed throughout the Lower Klamath tributaries, but occur at very low densities. This restricted spatial structure indicates that the population is at increased risk of extinction.

Very little is known about the life history and genetic diversity of the LKR population, but based on survey data the population has been affected by out-of-basin stock planting and hatchery influences. The reduced population abundance has likely led to depensation effects some years (e.g. inbreeding) and reduced genetic diversity. Compared with other Klamath populations, however, tributaries in the LKR subbasin may support some of the healthiest wild coho salmon in the basin. We also know that 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. Because genetic and life history diversity is important in building and maintaining resilience within a population, and is likely reduced from historical levels, the population is at increased risk of extinction based on its reduced capacity for resilience.

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 46,000 individuals from 2002 to 2006.

Consistent spawner survey 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.

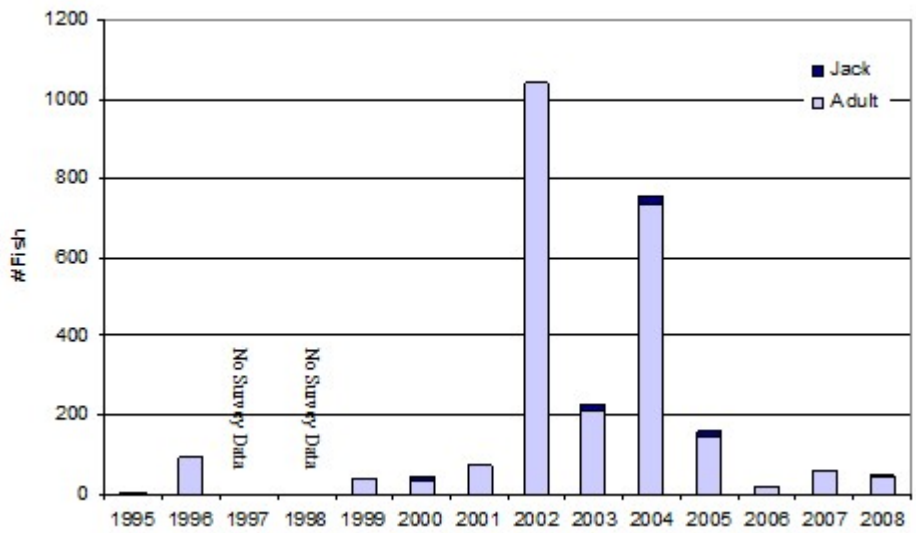

Figure 18-2. Coho salmon observed spawning in the Blue Creek watershed of the Lower Klamath River subbasin between 1995 and 2008. Data are from YTFP snorkel surveys (Gale et al. 1998, Gale 2009c).

Adult coho salmon population abundance, estimated by Ackerman et al. (2006), ranged from 15 to 1,500 spawners between 2001 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, a conclusion that is supported by the Blue Creek spawner data.

Table 18-4. Estimates of sub-yearling coho salmon abundance (Voight and McCanne 2002, 2006) and estimated adult abundance in LKR tributaries (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 subbasin 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 (Table 18-4).

The productivity of the population, based on the juvenile and adult abundance estimates, appears to be declining. Historic data indicate that populations were more abundant as recently as 50 years ago and results of recent data suggests that many populations have experienced low, highly variable abundances of coho salmon over the past decade. It is likely that the population has 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 is negative, the population is at increased risk of extinction.

Extinction Risk

The LKR coho salmon population is not viable and at high risk of extinction. The estimated average spawner abundance from the three lowest consecutive years within the past twelve years is likely less than the depensation threshold of 205 spawners, assuming marine survival of less than 1 percent (NMFS 2011).

Role of Population in SONCC Coho Salmon ESU Viability

The LKR population is considered a “Functionally Independent” population within the Central Coastal diversity stratum meaning that it was sufficiently large to be historically viable-in-isolation and has demographics and extinction risk that were minimally influenced by immigrants from adjacent populations (Bjorkstedt et al. 2005, Williams et al. 2006). Though strays have minimal influence on the LKR population, this subbasin 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 LKR is important for populations throughout the Klamath and Trinity subbasins. Coho salmon juveniles and smolts from upstream populations use the LKR subbasin 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, Soto et al. 2008, YTFP 2009a, Hillemeier et al. 2009, Silloway 2010, Belchik and Turo 2002). In addition, the LKR population is considered a core

population. For the stratum and ESU to be viable, the Lower Klamath population must be above its low risk threshold of 5,900 spawners.

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.

This 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.

This 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.

This 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.

This 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.

This 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 subbasin is private land; the majority of which is owned by Green Diamond. The Aquatic Habitat Conservation Plan, finalized in 2006 and valid through 2056, was developed in accordance with the ESA section 10 regulations which require Green Diamond to develop 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.

18.5 Stresses

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

Stresses (Limiting Factors)		Egg	Fry	Juvenile[1]	Smolt	Adult[1]	Overall Stress Rank
1	Altered Sediment Supply[1]	High	Very High	Very High[1]	Very High	High[1]	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	High	High	High
4	Impaired Estuary/Mainstem Function	-	Low	High	High	High	High
5	Altered Hydrologic Function	Medium	Medium	High	High	High	High
6	Impaired Water Quality	Low	Medium	High	Medium	Medium	Medium
7	Adverse Hatchery-Related Effects	Medium	Medium	Medium	Medium	Medium	Medium
8	Increased Disease/Predation/Competition	Low	Low	Medium	Medium	Medium	Medium
9	Barriers	-	Low	Medium	Medium	Medium	Medium
10	Adverse Fishery-Related Effects	-	-	-	-	Medium	Medium

[1]Key limiting factor(s) and limited life stage(s).

Limiting Stresses, Life Stages, and Habitat

Several key stresses limit the productivity of this population due to their impact on ecosystem function and on the growth and survival of certain life stages. Altered sediment supply and the lack of complex floodplain and channel structure (LWD) are primary stressors and the most likely limiting stresses due to their impacts on habitat necessary for coho salmon reproduction, growth, and survival in the Lower Klamath River (YTFP 1999, 2009b). Impaired estuary and mainstem conditions may also contribute to losses in the population due to the impact on survival. The overall population-level impact from the impaired estuary is unknown, but assumed to be large given the current state of the Klamath River estuary and its importance to growth and survival of juveniles and smolts. 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 (LWD), and impaired hydrologic function in the mainstem have led to subsurface flows from tributaries during periods of low to no precipitation, resulting in high stranding and mortality rates and reduced growth. Channel sedimentation and lack of channel structure (LWD) resulted in significant loss to overwintering

and summer rearing habitat as well. In some streams, the dewatering of tributary reaches substantially reduces summer rearing habitat and can occur so quickly that juveniles are unable to relocate. YTFP has documented substantial juvenile and some adult steelhead 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 in 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 (LWD), and the lack of floodplain and off-channel habitat availability results in most tributary stream reaches having minimal refuge habitat from elevated winter flows and/or turbidity. 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 increased flow events likely hinders winter/spring feeding potential and in turn may be responsible for the reduced growth rates that have been observed in tributary streams versus fish in off-channel habitat (Gale 2010, YTFP 1999, Pagliuco et al. 2011).

In many tributaries repeated aggradation and degradation has also led to floodplain conditions that preclude the establishment of viable and resilient riparian forests. Resulting poor LWD recruitment acts to perpetuate 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.

Looking at the overall productivity of the population, the three most limited life stages are eggs, fry, and juveniles. Spawning and incubation are limited by the lack of suitable spawning gravels due to bed coarsening and embeddedness. 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.

The primary limiting habitat types for the LKR population are high quality spawning and rearing habitat. It is important to note, the areas that provide valuable rearing habitat can be different from those areas that may provide spawning habitat, however a few key tributaries in the Lower Klamath provide the majority of these habitats to the population. These important tributaries include Tectah, Terwer, Hunter, McGarvey, and Blue creeks (YTFP 2009a). Small pockets of high quality spawning and rearing habitat also exist in Ah Pah, Mettah, Johnsons, High Prairie, Hoppaw, 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. Vital habitat is listed in Table 18-6 below.

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).

Because of seasonally elevated water temperatures in most of the mainstem Klamath River, many LKR tributaries and off-channel areas can serve as thermal refugia during the summer. These refugia areas 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 during critical summer months (May-September). Summer rearing habitat in these areas is also important for coho salmon (Silloway 2010, Hillemeier et al. 2009). Refugial areas 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 and low velocity refugia are important for non-natal populations and for the Lower Klamath population juveniles that get flushed out of, or actively leave their natal creeks (Pagliuco et al. 2011, Fiori et al. 2011a, Fiori et al. 2011b). During summer, Pine, Tully, Pecwan, Tectah, and Mettah juveniles have a long journey to reach the ocean.

Table 18-6. Potential vital habitat within the geographic boundaries of the LKR subbasin.

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]
W. Fork McGarvey Creek[1]	Blue Creek[1,2]	Bear Creek[1]
Terwer Creek[1,2,3]	Crescent City Fork[1,2]	Roaches Creek[2]
Hoppaw Creek[1]	EF Blue[1,2]	Mettah Creek[1]
Richardson Creek[1,2,3]	WF Blue[1,2]	Johnsons Creek[1]
Pine Creek[1,2]	Estuary Sloughs[1,2,3]	Cappell Creek[2]

[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 subbasin reduced quantity and quality of coho salmon habitat for all life stages; therefore, NMFS considers altered sediment supply to have an overall stress ranking of very high. 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 stream pool tailouts surveyed, 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 subbasin, the highest embeddedness (>50 percent) were Roaches, Pecwan, Cappel, WF 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. It is evident that 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 the summer (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 history 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 size range (14.5 – 35 mm) for salmonid spawning (Beesley and Fiori 2008a; Kondolf and Wolman 1993).

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 (Gale and Randolph 2000) found that LWD in the LKR tributaries ranged from 34 to 537 pieces/mile (average = 230). 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.

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 maximum depth (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. Looking at pool habitat complexity, the percentage of LWD as structural shelter in pools reflects the quantity and quality of potential salmonid habitat and possibly the effects of past management practices (GDRC 2006). Looking at these data, we see that most pools lack LWD; West Fork Blue Creek, Johnsons, Roaches, and Tully creeks have a notable lack of LWD in pools. 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 logging 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 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 (see above). 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 logging practices in the watershed (Beesley and Fiori 2008a). The lack

of riparian cover and forest regeneration in this area has impacted water quality during the summer (see below) and significantly reduced salmonid rearing capacity, especially during winter-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 largely intact and unaffected by urban development, several factors limit its ability to support properly functioning habitat for coho salmon (Hiner and Brown 2004, NFMS 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 a majority 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 a substantial precipitation event 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 flows in LKR tributaries 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 historical flows, while fall and winter flows in the Lower Klamath River are generally similar to historical flows. 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. 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 peak discharge levels of an increased intensity and 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, watersheds 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. 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. 2008, 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. Seasonally high water temperatures in the Lower Klamath River, the estuary, and in lower reaches of some LKR tributaries are a primary limitation for this and other Klamath Basin coho salmon populations. Generally, temperatures near the headwaters of LKR tributaries are mostly 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.

Data gathered from future and ongoing turbidity monitoring efforts by GDRC and the YTEP will be analyzed to determine if turbidity is an issue for tributaries in the Lower Klamath River. Based on current stream and river sedimentation conditions, it is likely that seasonally high turbidity levels in the Lower Klamath River, and in a majority of its tributaries, is a moderate stressor 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

The effects of hatchery fish on all life stages of coho salmon are described in Chapter 3. 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, which breaks from the Klamath upstream of the Lower Klamath River population area. 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 moderate stressor 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 pond 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 refugial areas prior to upstream migration due to hydrologic conditions that inhibit access to tributary spawning groups in the Lower Klamath.

Disease is a significant stressor 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 2003a, Belchik et al. 2004) although adult mortality from Ich and columnaris are not as common as juvenile mortality from Ceratomyxa 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, respectively. Pinniped predation rates offshore and in the open ocean may add to this predation. Also important may be increased seasonal predation rates on juveniles in streams due to the lack of cover and high densities of juveniles in some habitats. It is likely that predation rates are not unnaturally high but do contribute to a reduction in the number of adults returning to the Klamath Basin and the number of juveniles that survive.

Barriers

Barriers are a moderate 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

oversummer 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 deposition of sediment from the mainstem Klamath River and the 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 W. Fork McGarvey Creek blocks access to high IP reaches. Three undersized culverts (1 Saugep, 1 Waukell, and 1 Junior) and a grade control structure on Waukell Creek (Klamath Beach Road and Hwy 101), and an 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, the impact of these barriers is significant.

Adverse Fishery-Related Effects

NMFS has determined that federally-managed fisheries in California are not likely to jeopardize the continued existence of the SONCC coho salmon ESU (Appendix B). The effects of fisheries managed by the state of California and tribal governments on the continued existence of the SONCC coho salmon ESU have not been formally evaluated by NMFS (Appendix B).

18.6 Threats

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

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

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 subbasin 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, impacts to bank stability and sedimentation, as well as water quantity and fish passage issues related to diversion of water. Only a small portion of the Lower Klamath subbasin is suitable for agriculture but the impacts from agriculture affect some of the most important tributaries and off-estuary habitats for coho salmon. These include 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.

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 terrace 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 in Terwer, Blue, and Bear creeks. The 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, Pagliuco et al. 2011).

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. The cumulative sedimentation that has occurred over the past 50 years of road-building and intensive logging 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 subbasin exist on these lands. As part of the GDRC HCP (2006), the company has prioritized road upgrades and decommissioning for 30 subbasins 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 subbasin 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 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 subbasin 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).

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 subbasin and the impacts of these activities, even when carried out under the HCP guidelines, include the loss of pool habitat, loss of LWD and stream complexity, altered hydrology and nutrient cycling, and increased sediment loads.

Dams/Diversions

Dams and diversions pose a high threat to the population 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 diversion of water 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). Low dissolved oxygen, elevated summer/fall water temperatures, and high nutrients are some of the water quality issues exacerbated by the four 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 subbasin, and these are negligible compared to the Klamath, Trinity, Scott and Shasta diversions. The total amount of water diverted within the LKR area is not known, but is assumed minor relative to available water supply. Diversions to the Klamath Project in the Upper Klamath subbasin, 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 2010, NMFS 2009a). 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 subbasin 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 historical flows, while fall and winter flows in the Lower Klamath are generally similar to historical flows. The hydrologic function of

tributaries to the Lower Klamath has also been altered, as evidenced by downstream portions of tributaries going dry during late spring and summer (e.g., Terwer Creek).

Channelization/Diking

Channelization and diking pose a moderate 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).

These levees continue to reduce or eliminate hydrologic connectivity of floodplains, wetlands, and estuarine sloughs that provide essential ecosystem functions and productive juvenile rearing areas. Some natural dikes and channels have also formed as a result of excessive sedimentation and flow alterations. Numerous historic off-channel areas and tributaries are inaccessible permanently or seasonally due to inadequate flows and sediment accretion.

Climate Change

Climate change poses a medium to high 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. 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 subbasin, 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 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

California-managed fisheries for species other than coho salmon occur in estuaries, freshwater, and nearshore marine areas. In addition, tribal salmonid fisheries have the potential to cause injury and death to coho salmon in the Klamath Basin and Trinity subbasin. The effects of the fisheries managed by the State of California and the Yurok and Hoopa Tribes, on the continued existence of the SONCC coho salmon ESU have not been formally evaluated by NMFS. NMFS has authorized future collection of coho salmon for research purposes in the Lower Klamath River. NMFS has determined these collections are not likely to jeopardize the continued existence of the SONCC coho salmon ESU.

Road-Stream Crossing Barriers

Road-stream crossing barriers are a low to moderate 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 W. 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 for when backwatering occurs from the mainstem Klamath 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 subbasin, but are on streams where coho salmon have not been documented and no IP habitat exists (e.g., Burrill, Rube, Mareep, Knulthkarn). The passable culvert on Waukell, which is a barrier to stream function, will soon be addressed.

Table 18-8. List of road-stream crossing barriers in the LKR population area.

Priority	Stream Name	Barrier Type	Road Name	Miles of habitat above barrier
Low	Waukell Creek	Grade Control Structure	Hwy 101	<1.0
Low	Waukell Creek	Culvert	Hwy 101	<1.0
High	Richardson Creek	Culvert	Klamath Beach Rd	1.0
Low	McGarvey Creek	Grade Control Structure	Hwy 101	<1.0
High	Terwer	Bridge	Hwy 169	>1.0
High	Blue	Bridge	GDRC road	>1.0
High	Junior	Culvert	Unnamed	>1.0
Medium	Saugep	Culvert	Klamath Beach Rd	>1.0
Medium	Spruce	Culvert	Hwy 101	>1.0

Invasive Non-Native/Alien Species

A few non-native invasive species may be affecting this population. Bullfrog and Brown trout predation potentially have an effect on juvenile populations of 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 been undertaken to date. 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 Intensity Fire

The threat of high intensity fire in the Lower Klamath is minimal 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 it appears that spawning habitat and summer and winter rearing habitat may be limited by sediment loading and a lack of floodplain and channel structure. Currently, a few key tributaries support the majority of 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 of particular importance and can be accomplished by placing complex wood jams (CWJs) and/or engineered log jams (ELJs) 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 future LWD recruitment, and is a top priority. In addition, constructing off-channel ponds, wetlands, and side-channels, removing or setting back levees, decreasing sediment input, and stabilizing uplands are also recovery actions of high priority.

The removal of the four mainstem hydroelectric dams in the Upper Klamath is also important to the improvement of hydrologic function, water quality, and disease conditions in the mainstem Klamath and estuary. 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 subbasin for non-natal rearing and as migratory habitat. In addition to restoration, recovery actions in the LKR should focus on protecting those tributaries that have been identified as being strongholds for the population.

To improve the viability of this population it will be imperative to address these limiting stressors and to improve habitat conditions for these life stages throughout the subbasin. 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.

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.

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID	***Step Description***					
SONCC-LKR.2.1.1	Floodplain and Channel Structure	Yes	Increase channel complexity	Increase LWD, boulders, or other instream structure	Mainstem Klamath River, Estuary, and lower Klamath River tributaries	2
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.2.2.2	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Construct off channel ponds, alcoves, backwater habitat, and old stream oxbows	Mainstem Klamath River, Estuary, and lower Klamath River tributaries	2
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 as guided by assessment results*					
SONCC-LKR.2.2.3	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Construct off channel ponds, alcoves, backwater habitat, and old stream oxbows	Mainstem Klamath River, Estuary, and lower Klamath River tributaries	3
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.*					
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	2
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 CWJs or ELJs 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.2.2.6	Floodplain and Channel Structure	Yes	Reconnect the channel to the floodplain	Increase beaver abundance	Mainstem Klamath River, Estuary, and lower Klamath River tributaries	3
SONCC-LKR.2.2.6.1	*Develop program to educate and provide incentives for landowners to keep beavers on their lands*					
SONCC-LKR.2.2.6.2	*Implement beaver program (may include reintroduction)*					

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID	***Step Description***					
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	*Limit hunting or removal of beaver*					
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 Prarie, Hunter, Mynot, Hoppaw, Waukell	3
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 have been removed*					
SONCC-LKR.2.2.8.2	*Remove levees and restore channel form and floodplain connectivity*					
SONCC-LKR.8.1.9	Sediment	Yes	Reduce delivery of sediment to streams	Quantify dominant sediment sources and sinks	Population wide	3
SONCC-LKR.8.1.9.1	*Complete sediment budget*					
SONCC-LKR.8.1.10	Sediment	Yes	Reduce delivery of sediment to streams	Reduce erosion	Lower Klamath River sub-basin	2
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.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)	2
SONCC-LKR.8.1.11.1	*Assess and prioritize road-stream connection, and identify appropriate treatment to meet objective*					
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.8.1.12	Sediment	Yes	Reduce delivery of sediment to streams	Improve regulatory mechanisms	Population wide	3
SONCC-LKR.8.1.12.1	*Develop grading ordinance for maintenance and building of private roads that minimizes the effects to coho*					

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID	***Step Description***					
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, Salt, Hunter, Hoppaw, Tarup, Omagaar)	3
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.1.2.39	Estuary	No	Improve estuarine habitat	Assess estuary and tidal wetland habitat	Estuary	3
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*					
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	3
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 fishing impacts expected to be consistent with recovery*					
SONCC-LKR.16.1.26	Fishing/Collecting	No	Manage fisheries consistent with recovery of SONCC coho salmon	Limit fishing impacts to levels consistent with recovery	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	2
SONCC-LKR.16.1.26.1	*Determine actual fishing impacts*					
SONCC-LKR.16.1.26.2	*If actual fishing impacts exceed levels consistent with recovery, modify management so that levels are consistent with recovery*					
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	3
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 scientific collection impacts expected to be consistent with recovery*					

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID	***Step Description***					
SONCC-LKR.16.2.28	Fishing/Collecting	No	Manage scientific collection consistent with recovery of SONCC coho salmon	Limit impacts of scientific collection to levels consistent with recovery	SONCC recovery domain plus ocean; from shore to 200 miles off coasts of California and Oregon	3
SONCC-LKR.16.2.28.1	*Determine actual impacts of scientific collection*					
SONCC-LKR.16.2.28.2	*If actual scientific collection impacts exceed levels consistent with recovery, modify collection so that impacts are consistent with recovery*					
SONCC-LKR.3.1.19	Hydrology	No	Improve flow timing or volume	Increase instream flows	Lower Klamath Tributaries (e.g.Hoppaw, Tarup, Omagaar, Bear, Hunter, Mynot, Johnsons)	3
SONCC-LKR.3.1.19.1	*Identify diversions in tributaries that have subsurface or low flow barrier conditions during the summer*					
SONCC-LKR.3.1.19.2	*Reduce diversions*					
SONCC-LKR.3.1.20	Hydrology	No	Improve flow timing or volume	Educate stakeholders	Population wide	3
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	3
SONCC-LKR.3.1.21.1	*Prioritize and provide incentives for use of CA Water Code Section 1707*					
SONCC-LKR.3.1.22	Hydrology	No	Improve flow timing or volume	Improve regulatory mechanisms	Population wide	3
SONCC-LKR.3.1.22.1	*Establish a categorical exemption under CEQA for water leasing*					
SONCC-LKR.3.1.23	Hydrology	No	Improve flow timing or volume	Improve regulatory mechanisms	Population wide	3
SONCC-LKR.3.1.23.1	*Establish a comprehensive statewide groundwater permit process*					
SONCC-LKR.27.1.29	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Estimate abundance	Population wide	3
SONCC-LKR.27.1.29.1	*Perform annual spawning surveys*					

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID		***Step Description***				
SONCC-LKR.27.1.30	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Develop survival estimates	Site to be determined	3
SONCC-LKR.27.1.30.1		*Install and annually operate a life cycle monitoring (LCM) station*				
SONCC-LKR.27.1.31	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Track life history diversity	Population wide	3
SONCC-LKR.27.1.31.1		*Describe annual variation in migration timing, age structure, habitat occupied, and behavior*				
SONCC-LKR.27.1.32	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Track indicators related to the stress 'Fishing and Collecting'	Population wide	2
SONCC-LKR.27.1.32.1		*Annually estimate the commercial and recreational fisheries bycatch and mortality rate for wild SONCC coho salmon.*				
SONCC-LKR.27.1.32.2		*Annually estimate the in-river tribal harvest of wild/natural SONCC coho salmon*				
SONCC-LKR.27.2.33	Monitor	No	Track habitat condition	Track habitat indicators related to spawning, rearing, and migration	Population wide	3
SONCC-LKR.27.2.33.1		*Measure indicators for spawning and rearing habitat. Conduct a comprehensive survey*				
SONCC-LKR.27.2.33.2		*Measure indicators for spawning and rearing habitat once every 10 years, sub-sampling 10% of the original habitat surveyed*				
SONCC-LKR.27.2.34	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Lack of Floodplain and Channel Structure'	All IP habitat	3
SONCC-LKR.27.2.34.1		*Measure the indicators, pool depth, pool frequency, D50, and LWD*				
SONCC-LKR.27.2.35	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Degraded Riparian Forest Condition'	All IP habitat	3
SONCC-LKR.27.2.35.1		*Measure the indicators, canopy cover, canopy type, and riparian condition*				
SONCC-LKR.27.2.36	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Altered Sediment Supply'	All IP habitat	3
SONCC-LKR.27.2.36.1		*Measure the indicators, % sand, % fines, V Star, silt/sand surface, turbidity, embeddedness*				

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID		*Step Description*				
SONCC-LKR.27.2.37	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Impaired Hydrologic Function'	All IP habitat	3
SONCC-LKR.27.2.37.1		*Annually measure the hydrograph and identify instream flow needs*				
SONCC-LKR.27.2.38	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Impaired Estuarine Function'	All IP habitat	3
SONCC-LKR.27.2.38.1		*Identify habitat condition of the estuary*				
SONCC-LKR.27.2.41	Monitor	No	Track habitat condition	Track habitat indicators related to the stress 'Impaired Water Quality'	All IP habitat	3
SONCC-LKR.27.2.41.1		*Measure the indicators, pH, D.O., temperature, and aquatic insects*				
SONCC-LKR.27.1.42	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Track indicators related to the stress 'Disease'	All IP habitat	3
SONCC-LKR.27.1.42.1		*Annually estimate the infection and mortality rate of juvenile coho salmon from pathogens, such as Ceratomyxa shasta and Parvicapusla minibicornis*				
SONCC-LKR.27.1.43	Monitor	No	Track population abundance, spatial structure, productivity, or diversity	Refine methods for setting population types and targets	Population wide	3
SONCC-LKR.27.1.43.1		*Develop supplemental or alternate means to set population types and targets*				
SONCC-LKR.27.1.43.2		*If appropriate, modify population types and targets using revised methodology*				
SONCC-LKR.27.2.44	Monitor	No	Track habitat condition	Determine best indicators of estuarine condition	Estuary	3
SONCC-LKR.27.2.44.1		*Determine best indicators of estuarine condition*				
SONCC-LKR.5.1.40	Passage	No	Improve access	Remove barriers	Population wide	3
SONCC-LKR.5.1.40.1		*Evaluate and prioritize barriers for removal*				
SONCC-LKR.5.1.40.2		*Remove barriers, guided by the assessment*				

Action ID	Strategy	Key LF	Objective	Action Description	Area	Priority
Step ID		***Step Description***				
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	3
SONCC-LKR.7.1.14.1		*Determine appropriate silvicultural prescription for benefits to coho salmon habitat*				
SONCC-LKR.7.1.14.2		*Thin, or release conifers, guided by prescription*				
SONCC-LKR.7.1.14.3		*Plant conifers, guided by prescription*				
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)	3
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 plan to meet objective*				
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*				
SONCC-LKR.7.1.16	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Revegetate riparian areas	Mainstem Klamath River and Blue Creek	3
SONCC-LKR.7.1.16.1		*Control feral cattle to rehabilitate riparian forests*				
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*				
SONCC-LKR.7.1.18	Riparian	No	Improve wood recruitment, bank stability, shading, and food subsidies	Improve timber harvest practices	Population wide	2
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).*				