UPPER KLAMATH-TRINITY RIVERS SPRING-RUN CHINOOK SALMON
***Oncorhynchus tshawytscha* (Walbaum)**

Status: Critical Concern. Small, self-sustaining, wild populations occur in the Salmon River and South Fork Trinity, where they are highly vulnerable to climate change, poaching, and other stressors. Recent basin-wide abundances are thought to be approximately 3% of historical run size.

Description: Chinook salmon have numerous, small, black spots on the back, dorsal fin and both lobes of the tail in both sexes. This spotting on the caudal fin and black coloration of the lower jaw make Chinook distinguishable from other sympatric salmonid species. Klamath River Chinook possess significant differences from Sacramento River Chinook in the number of gill rakers and pyloric caeca, with 12-13 rough, widely spaced gill rakers on the lower half of the first gill arch and 93-193 pyloric caeca (Snyder 1931, McGregor 1923). Dorsal fin ray, anal fin ray and branchiostegal counts are significantly different from Columbia River Chinook (Snyder 1931, Schreck et al. 1956). They have 10-14 major dorsal fin rays, 13-16 anal fin rays, 14-19 pectoral fins rays and 10-11 pelvic fin rays. Branchiostegal rays number 13-18 and there are 131-147 scales along the lateral line.

Spawning adult Chinook are the largest Pacific salmon, typically 75-80 cm SL, but lengths may exceed 140 cm. Klamath River Chinook spawning adults are considered to be smaller, more rounded, and heavier in proportion to their length compared to Sacramento River Chinook (Snyder 1931). In 2004, Trinity River fall-run Chinook averaged 69 cm FL, with a maximum grilse size of 56 cm FL (CDFG 2006). Adults are olive brown to dark maroon without streaking or blotches on the side. Males are often darker than females and develop a hooked jaw and slightly humped backs during spawning. Juvenile Chinook have 6-12 parr marks, often extending below the lateral line and they are typically equal to or wider than the spaces between. Occasionally, parr will have spots on their adipose fin; however, a more distinguishing adipose fin character is that of a pigmented upper edge and clear center and base.

Upper Klamath-Trinity rivers (UKTR) spring-run Chinook salmon enter natal streams during spring and early summer months as silvery, sexually immature adults and lack the breeding colors or elongated kype seen in fall-run Chinook salmon (Snyder 1931).

Taxonomic Relationships: The UKTR Chinook salmon ESU includes all naturally spawned populations of Chinook salmon in the Klamath River basin, upstream from its confluence with the Trinity River. This ESU is genetically distinguishable from other California Chinook ESUs (Waples et al. 2004).

Within the UKTR Chinook ESU, genetic analyses have demonstrated that stock structure mirrors geographic distribution (Banks et al. 2000). Fall- and spring-run Chinook salmon from the same subbasin appear more closely related to one another than each is to fall or spring-run Chinook from adjacent basins. This pattern is distinct from Chinook of different run timings in the Sacramento and Columbia rivers, where spring-run Chinook from different basins are more similar to one another than they are to fall-run Chinook within the same basin. Furthermore, fall-run Chinook salmon populations from both the Klamath and Trinity subbasins appear more similar to the respective spring-run Chinook populations within a given subbasin than they are to fall-run Chinook in Lower Klamath River tributaries.

Despite the lack of strong genetic differentiation from UKTR fall-run Chinook, the UKTR spring-run is treated here as a distinct taxon because it represents a life history strategy that is an essential adaptive component of the ESU and requires separate management strategies.

Life History: Adult UKTR spring-run Chinook salmon enter fresh water before their gonads are fully developed and hold in cold water streams for 2-4 months before spawning. They enter the Klamath estuary during spring and summer months, beginning in March and tapering off in July, with a peak between May and early June (Moffett and Smith 1950, Myers et al. 1998). A majority of late-entry fish are apparently of hatchery origin (Barnhardt 1994, NRC 2004). Leidy and Leidy (1984) noted that adult Trinity River spring-run Chinook migration continued until October. However, given this late-entry timing, it is unclear if these fish are sexually mature and capable of spawning with spring-run Chinook adults already in the system. Because this late spring-run type is limited to the Trinity River, it is possible these fish represent hybrid spring and fall-run Chinook from hatchery stocks. Biologists at the Trinity River Hatchery (TRH) classified Chinook salmon entering between September 3 and October 15, 2004, as spring-run Chinook (CDFG 2006). However, entry timing into the hatchery was artificially delayed until early September due to the fish ladder being closed. Spring–run Chinook have not been successfully held over for long periods of time in the hatchery due to space constraints and mortality (W. Sinnen, CDFW, pers. comm. 2013). Moffett and Smith (1950) noted that spring-run Chinook migrated quickly through the watershed; more recent work (Strange 2005) has confirmed this rapid migration pattern in the Trinity River. While migration occurred throughout the day and night, there was a peak in movement during the two hours following sunset (Moffett and Smith 1950).

Spawning starts in mid-September in the Salmon River. Spring-run Chinook in the South Fork Trinity River begin spawning in late September, with a peak in mid-October (LaFaunce 1967). Trinity River spawning typically is 4-6 weeks earlier than that of fall-run UKTR Chinook in the same basin (Moffett and Smith 1950). Overlap between fall and spring-run Chinook spawning areas was historically minimal. In the South Fork Trinity River, the majority of spring-run Chinook spawning occurred upstream of Hitchcock Creek, above Hyampom Valley, while fall-run Chinook spawned below this point (LaFaunce 1967, Dean 1996). However, Moffett and Smith (1950) noted that spawning of the fall and spring-runs overlapped in October on suitable spawning riffles between the East Fork and North Fork Trinity River and that redd superimposition and hybridization may have occurred. In the Salmon River, overlap exists between spawning times of fall- and spring-run Chinook, although redds constructed upstream of the confluence of Matthews Creek are predominantly those of spring-run Chinook (Olson et al. 1992). Overall, spatial separation between the two runs in the Klamath-Trinity system occurs at approximately 518 m elevation.

Upper Klamath-Trinity rivers spring-run Chinook fry emerge from gravels from early winter (Leidy and Leidy 1984) until late-May (Olson 1996). With optimal conditions, embryos hatch after 40-60 days and remain in the gravel as alevins for another 4-6 weeks, usually until the yolk sac is fully absorbed. Before Lewiston Dam became the upper limit for migration on the Trinity River, emergence upstream of Lewiston began in early January; Moffett and Smith (1950) speculated that these early fish were offspring of UKTR spring-run Chinook. More recent reports (Leidy and Leidy 1984) suggest emergence begins as early as November in the Trinity River and December in the Klamath River, lasting until February.

Unlike most spring-run Chinook populations north of the Klamath River (e.g., Columbia River), UKTR spring-run Chinook do not consistently display "stream type" juvenile life histories, where juveniles spent at least one year in streams before migrating to the ocean (Olson 1996). Juvenile emigration occurs primarily from February through mid-June (Leidy and Leidy 1984). Natural-spawned juvenile Chinook salmon were not observed emigrating past Big Bar (rkm 91) earlier than the beginning of June, with a peak in mid-July from 1997-2000 (USFWS 2001). In the Salmon River, two peaks of juvenile emigration have been observed: spring/early summer and fall. Snyder (1931) examined scales from 35 adult spring-run Chinook and 83% displayed juvenile "ocean type" growth patterns, in which juveniles entered the ocean just a few months after emerging from the gravel. In the Salmon River, an otolith study (Sartori unpublished data) identified 31% of fall-emigrating juvenile Chinook salmon as having similar growth patterns to Salmon River spring-run Chinook, suggesting these were 'ocean-type' juveniles.

Other life history attributes are similar to UKTR fall-run Chinook and other Chinook salmon taxa (Moyle 2002).

Habitat Requirements: UKTR spring-run Chinook enter the Klamath estuary when river water temperatures are at or above optimal holding temperatures (10-16°C; McCullough 1999). Temperatures in the Lower Klamath River typically rise above 20°C in June and can reach 25°C during August. Spring-run Chinook use thermal refuges in the estuarine salt wedge and associated nearshore ocean habitats prior to entering fresh water (Strange 2003). Strange (2005) found adult migration changed with different temperature trajectories. When daily water temperatures were increasing, Chinook migrated upstream until temperatures reached 22°C. When temperatures were decreasing, fish continued to migrate upstream at water temperatures of up to 23.5°C. A cool water refuge at the confluence of Blue Creek was used by 38% of spring-run Chinook for more than 24 hours in 2005 (Strange 2005). Optimal adult holding habitat is characterized by pools or runs >1 m deep with cool summer temperatures (<20°C), all-day riparian shade, little human disturbance, and underwater cover such as bedrock ledges, boulders or large woody debris (West 1991). Because the Salmon River and its forks regularly warm to summer daytime peaks of 21-22°C, the best holding habitats are deep pools that have cold water sources, such as those at the mouths of tributaries or those deep enough to thermally stratify.

For UKTR spring-run Chinook, spawning habitat is mainly comprised of low gradient gravelly riffles or pool tail-outs. Spawning and redd construction appear to be triggered by a change in water temperature rather than an increase in flows. Therefore, redd superimposition may occur when flows are low, limiting suitable habitat to that around holding pools. Redd superimposition has been noted for spring-run Chinook spawning in the South Fork Trinity River (Dean 1995). West (1991) noted that spring-run Chinook survival to emergence ranged from 2-30% on the Salmon River in 1990. Juvenile habitat requirements for spring-run UKTR Chinook salmon are similar to those of fall-run UKTR Chinook salmon.

Distribution: Upper Klamath-Trinity rivers spring-run Chinook were once found throughout the Klamath and Trinity basins in suitable reaches of larger tributaries (e.g., Salmon River) or, flows permitting, utilizing smaller tributaries for holding and spawning. Historically, they were apparently abundant in the major tributary basins of the Klamath and Trinity rivers, such as the Salmon, Scott, Shasta, South Fork and North Fork Trinity rivers (Moffett and Smith 1950, Campbell and Moyle 1991). Their distribution is now restricted by dams, which block access to

the upper Klamath and Trinity rivers. Passage of spring-run Chinook, through Upper Klamath Lake, to access holding and spawning grounds in the Sprague, Williamson and Wood rivers, was blocked in 1918 by completion of Copco 1 Dam (Hamilton et al. 2005). Currently, the Salmon River and its two forks and the South Fork Trinity River maintain self-sustaining populations in the Klamath River basin, with little hatchery influence. Approximately 177 km of habitat is accessible to spring-run Chinook in the Salmon River (West 1991) but most of it is underutilized or unsuitable. The South Fork Salmon River supports the majority of the spawning population, although spring Chinook redds have been found in some smaller tributaries of the Salmon River basin including Nordheimer, Knownothing, and Methodist creeks. In addition, there are dwindling populations of spring-run Chinook in Elk, Indian, Clear and Wooley creeks.

In the Trinity River basin, spring-run Chinook salmon historically spawned in the East Fork, Stuart Fork, Coffee Creek and the mainstem upper Trinity River (Campbell and Moyle 1991). The completion of Trinity Dam in 1962 and Lewiston Dam in 1963 blocked access to 56 km of what was considered to be prime spawning and nursery habitat on the mainstem as earlier recorded by Moffett and Smith (1950). Currently, Trinity River spring-run Chinook are present in small numbers in Hayfork and Canyon creeks, as well as in the North Fork Trinity, South Fork Trinity and New rivers, but only the South Fork population appears to maintain itself through naturally-spawned fish (W. Sinnen, CDFW, pers. comm. 2013). LaFaunce (1967) found spring-run Chinook spawning in the South Fork Trinity River, from about 3 km upstream of Hyampom and in Hayfork Creek up to 11 km above its mouth. The highest density of redds in the South Fork Trinity was between 60.7 and 111.8 rkms in 1964 (LaFaunce 1967) and 1995 (Dean 1995).

Trends in Abundance: UKTR spring-run Chinook populations once likely totaled greater than 100,000 fish (Snyder 1931, Moyle 2002). The spring-run was thought to be the main run of Chinook salmon in the Klamath River, but the stocks had been depleted by the early 20th century as the result of irrigation, overfishing, mining, and other causes (Snyder 1931). Historic run sizes were estimated by CDFW to be at least 5,000 in each of the following Klamath tributaries: Sprague River (Oregon), Williamson River (Oregon), Shasta River and Scott River (CDFG 1990). The runs in the Sprague, Wood, and Williamson rivers were extirpated after the construction of Copco 1 Dam in 1918. Approximately 500 fish returned to Iron Gate Hatchery each year during the 1970s (Hiser 1985), but the hatchery was not able to maintain this run without a source of cold summer water. The last spring-run Chinook returned to the hatchery in 1978. The run in the Shasta River, probably the largest in the middle Klamath drainage, disappeared in the early 1930s as the result of habitat degradation and blockage of access to upstream spawning areas by Dwinnell Dam, which was erected in 1926. The smaller Scott River run was extirpated in the early 1970s from a variety of anthropogenic causes that depleted flows and altered habitats (Moyle 2002). In the middle reaches of the Klamath, spring-run Chinook have been extirpated from their historic habitats except the Salmon River and one of its tributaries, Wooley Creek (NRC 2004). Less than 10 spring-run Chinook are annually observed in Elk, Indian, and Clear creeks (Campbell and Moyle 1991).

In the Salmon River, spring-run Chinook summer counts are highly variable over time (Figure 1). Both the lowest (90 in 2005) and highest (1593 in 2011) numbers on record have been documented in recent years. Overall, the number of spring-run Chinook salmon adults appears to be increasing ($p = 0.0015$; Quiñones 2011), but numbers continue to be a fraction of historical runs (Hamilton et al. 2011). Quiñones (2013) found significant cross correlation ($r(27) = 0.50$, $p = <0.05$) between spring-run Chinook returning to the Salmon River and TRH returns

but trends may reflect similar responses of both wild and hatchery-reared fish to changing environmental conditions, rather than hatchery supplementation. Spring-run Chinook adult return numbers to the Trinity River were also significantly correlated to spring-run Chinook returns to TRH ($r(23) = 0.83$, $p = <0.05$). Spring-run Chinook returns to TRH fluctuated during the years of 1985 (increase), 1986 (increase), 1989 (decrease) and 1990 (increase), while Salmon River spring-run Chinook steadily increased over the same time period. The 1989 (decrease) and 1990 (increase) in returns of Spring-run Chinook to TRH may be explained by ocean conditions during those years. However, other increases (1985, 1986) likely reflected modification of hatchery infrastructure (construction of cement raceways) in the early 1980s that improved hatchery production (N. Hemphill, Trinity River Restoration Program, pers. comm. 2010) and probably led to an increase in short-term adult returns.

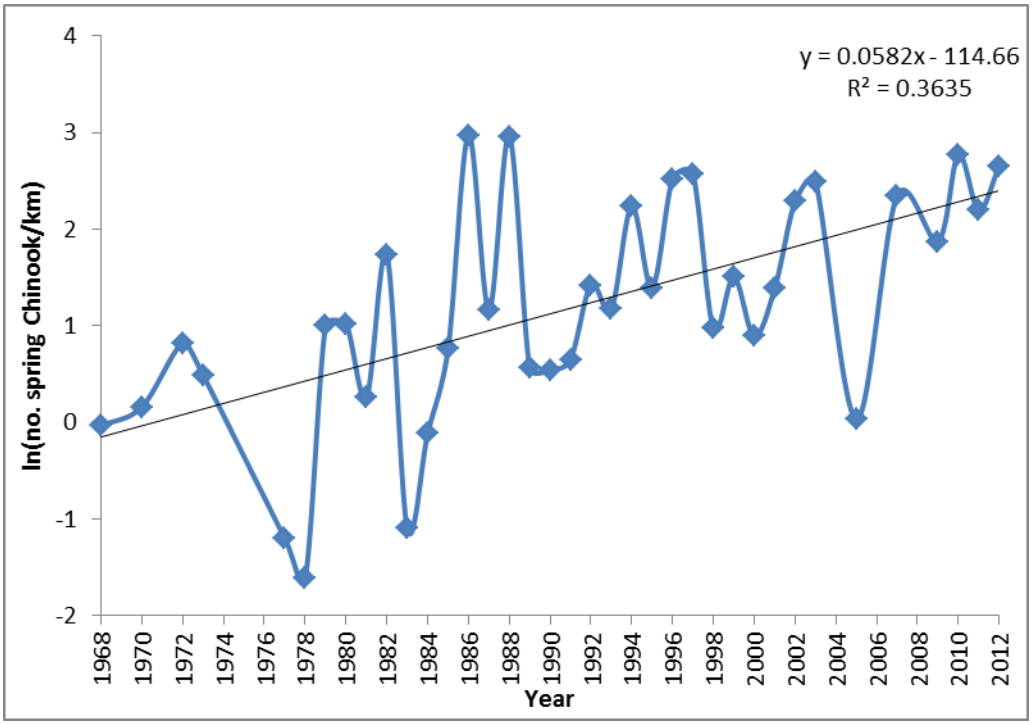

Figure 1. Number (ln) of spring-run Chinook salmon per kilometer observed in the Salmon River basin, excluding Wooley Creek, 1968-2012 (see Quiñones et al. 2013 for methods).

In the Trinity River, spring Chinook runs above Lewiston Dam have been extirpated but historically included more than 5,000 adults in the upper Trinity River and 1,000-5,000 fish in each of the Stuart Fork Trinity River, East Fork Trinity River and Coffee Creek (CDFG 1990). An average of 263 fish have been counted annually, over roughly the last thirty years, in the South Fork Trinity River, with runs as low as 59 (1988, 2005) and as high as 1097 (1996). Between 1980 and 1989, an average of 142 spring-run Chinook were counted annually in the South Fork Trinity River; 351 fish between 1990 and 1999; and, more recently, 232 fish between 2000-2005. Historically, 7,000-11,000 spring-run Chinook entered this stream (LaFaunce 1967) and outnumbered fall-run Chinook in the watershed. From 1980-2004, an average of 18,903 Chinook with spring-run life history returned above Junction City on the mainstem Trinity River.

In 2004, 16,147 spring-run Chinook salmon were estimated to migrate into this area, with 6,019 fish (37%) classified as spring-run Chinook entering Trinity River Hatchery.

While spring-run Chinook salmon are still scattered throughout the lower Klamath and Trinity basins, the only viable wild population appears to be limited to the Salmon River and South Fork Trinity River. Mainstem Trinity River numbers are presumably largely influenced by fish from the TRH, as are most tributary populations. Even if Trinity River tributary spawners are considered to be wild fish, the total number of spring-run Chinook in the UKTR system rarely exceeds 1000 fish and may drop to <300 in many years. Even recent large runs (~2500) of spring Chinook returning to the South Fork Trinity and Salmon River, combined, represent less than 3% of the total number of spring Chinook historically spawning in the basin.

In recent years, efforts have been made to compile spring-run Chinook numbers for all survey areas in a "mega-table" maintained by CDFW. However, these numbers represent varying degrees of effort (number of stream miles surveyed) between years, even within the same location, making trend analysis without standardization of the data unreliable (e.g., number of fish per kilometer; R. Quiñones, pers. observations, 2001-2011).

Nature and Degree of Threats: UKTR spring-run Chinook have been largely extirpated from their historic range because their life history makes them extremely vulnerable to the combined impacts from dams, mining, habitat degradation and fisheries, as well as many other anthropogenic (Table 1) and natural factors (e.g., ocean conditions).

Dams. A significant portion of the historic UKTR spring-run Chinook range has been lost behind Lewiston, Iron Gate and Dwinnell dams. Iron Gate Dam blocked access to the largest amount of habitat and there are currently about 970 km of anadromous habitats of varying quality upstream of it and three other dams (Hamilton et al. 2005). These barriers to adult holding and spawning habitats, as well as juvenile nursery areas, have reduced the resilience of spring-run Chinook populations due to smaller population sizes, loss of available habitat, and reduction in spatial segregation between spring and fall-run Chinook. This has likely led to significant interbreeding between fall- and spring-run Chinook in the Trinity River (Myers et al. 1998). Dams and diversions have also led to the extirpation of spring-run Chinook in the Klamath and Shasta rivers due to alteration of water quality and temperature, channel simplification, and disconnection of mainstem river channels from floodplains below dams.

Alternately, there is potential for UKTR spring-run Chinook salmon to be restored to large portions of their former range in the Klamath-Trinity basins through dam removal, especially on the mainstem Klamath, and habitat restoration.

Agriculture. Most spring-run Chinook holding and rearing habitats are upstream of areas heavily influenced by agriculture (e.g., Scott and Shasta valleys); nonetheless, pasture and crops along the Shasta and Scott rivers are irrigated with cold water from rivers that would otherwise be available for instream flow. Agricultural return waters are generally warm, with low water quality and often deliver pesticides, fertilizers and other pollutant to streams.

Rural development. The long history of mining and logging in the Klamath and Trinity basins has left an extensive network of roads which continue to provide access to many remote areas, facilitating rural development throughout these basins. Widespread rural development, particularly in the steep, mountainous terrain that characterizes this geographic area, may have substantial impacts on streams through increased surface run-off, sedimentation, effluent from septic tanks and other pollutants, water diversion, deforestation and habitat fragmentation.

	Rating	Explanation
Major dams	High	Large portions of historic range are blocked by dams
Agriculture	Medium	Agriculture along major tributaries reduces habitat quality and quantity through diversions, warm return waters and pollutants
Grazing	Medium	Grazing and irrigated pasture are pervasive on public and private lands in this region
Rural residential	Low	Cumulative effects of roads and widespread rural development pose ongoing and chronic threats
Urbanization	Low	Urban areas are few and restricted to main rivers
Instream mining	Medium	Dredge mining currently banned in CA; however, legacy effects remain in many areas; gravel mining may cause localized impacts
Mining	Medium	Legacy effects of intensive and widespread gold mining remain severe in some areas
Transportation	Medium	Roads present along many streams; impacts from increased run-off, sedimentation and habitat fragmentation
Logging	High	Both legacy and ongoing impacts have dramatically altered and degraded salmon habitats
Fire	Low	Climate change may contribute to increased fire frequency and intensity, potentially affecting headwater holding areas
Estuary alteration	Low	The Klamath River estuary is less altered than most north coast estuaries
Recreation	Medium	May be a chronic source of disturbance for some populations
Harvest	Medium	Legal and illegal harvest take many fish; evidence of poaching is annually found in the Salmon River basin (R. Quiñones, pers. obs.)
Hatcheries	High	Spring Chinook stocks are supplemented by TRH production; potential reduction in fitness and enhancement of spring-run/fall-run interbreeding
Alien species	Low	Few alien species in Klamath and Trinity rivers

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of UKTR spring-run Chinook salmon in California. Factors were rated on a five-level ordinal scale where a factor rated "critical" could push a species to extinction in 3 generations or 10 years, whichever is less; a factor rated "high" could push the species to extinction in 10 generations or 50 years whichever is less; a factor rated "medium" is unlikely to drive a species to extinction by itself but contributes to increased extinction risk; a factor rated "low" may reduce populations but extinction is unlikely as a result. A factor rated "n/a" has no known negative impact. Certainty of these judgments is moderate. See methods section for descriptions of the factors and explanation of the rating protocol.

Logging. Logging and associated road building have dramatically altered aquatic habitats in the Klamath and Trinity River basins (NRC 2004). Intensive and widespread logging began in the mid-19th century and legacy effects continue to affect rivers and streams in this region. Historic logging and the development of most early access roads occurred with little regard for environmental impacts. The steep and unstable slopes of this region, combined with local geology, make them particularly prone to erosion following road development and timber harvest (NRC 2004). Primary and ongoing impacts from this long history of timber operations in the Klamath-Trinity province include: increased erosion rates (delivering large amounts of

sediments into streams which often imbed spawning areas and fill pools needed by holding adults in the summer), increased surface run-off of precipitation (and corresponding decreased aquifer recharge capacity, leading to increased frequency of flash flooding in streams), and increased summer stream temperatures due to lack of aquifer recharge and reduced canopy and riparian vegetation (instream shading). Thus, the low numbers of spring-run Chinook salmon currently using the heavily-logged South Fork Trinity River may be due to severe habitat degradation from the catastrophic 1964 flood, which altered channel morphology and hydrology and triggered landslides that filled in holding pools and covered spawning beds. Without the influence of long-standing timber harvest in this drainage, the impacts of the 1964 flood would likely have been considerably reduced. Other logging impacts include elimination of large, senescent trees that, under natural forest succession conditions, historically provided large wood as cover in streams for salmon and corresponding habitat complexity for all life history stages. As discussed in the UKTR fall-run Chinook salmon account, increasing stream temperatures are a growing threat to salmonids in these basins.

Fire. Altered forests in the region have also become more prone to large-scale catastrophic fires and increased erosion as a result. For example, over 50% of the Salmon River watershed, one of the few remaining strongholds in the Klamath Basin for UKTR spring-run Chinook, has been severely burned in the past 100 years (NRC 2004).

Mining. Mining has dramatically altered river and stream habitats in the Klamath-Trinity Province, with lasting legacy impacts in many areas. Intensive hydraulic and dredge mining for gold occurred in the 19th century and, depending on location, these activities caused severe stream degradation and alteration to channel morphology. Mining was a principal cause of decline of spring-run Chinook in the Scott River and large areas in the Trinity River, followed by some level of recovery after large-scale mining ceased. The Scott River was heavily altered in the Scott River Valley and remains so today, where a degraded river winds through immense piles of dredge tailings. Historic mining impacts still affect the Salmon River spring-run Chinook population as the estimated 16 million cubic yards of sediment disturbed between 1870 and 1950 are slowly transported through the basin (J. West, U.S.F.S., pers. comm. 1995). Mining and its legacy effects have disconnected and constricted juvenile salmon habitats, filled in adult holding habitats, degraded spawning grounds and altered the annual hydrograph of many streams. Pool in-filling is a particular problem because high stream temperatures have been demonstrated to reduce survival of both holding adults and rearing juveniles (West 1991, Elder 2002).

Although greatly reduced in scale from the past, mining continues in the region and may pose an increasing threat as the price of gold has increased sharply in recent years. Instream suction dredge mining has been particularly damaging to spring-run Chinook habitats, although suction dredging is currently under a moratorium in California. Suction dredging may cause chronic unnatural disturbance (noise, turbidity, sediment movement) in stream habitats that are already stressed by other factors and can, therefore, negatively impact fishes, benthic macroinvertebrates and other aquatic organisms (Harvey and Lisle 1998). Direct effects may include entrainment and possible mortality of invertebrates (food for juveniles) and small fish in dredges, habitat alteration including changes to channel structure and complexity, and increased turbidity, which may interfere with foraging of juvenile salmon and other fishes. Suction dredging (and the accompanying presence of people in stream channels, often for long periods of time) can also present a continuous disturbance to holding adults and juveniles during summer, increasing stress and probability of premature mortality. Of particular concern, in the Klamath,

Salmon and Scott rivers and their tributaries, is the creation of piles of suction dredge tailings that may be utilized by spawning salmonids. Although these tailing piles are often comprised of suitable substrates for salmon redd creation and successful spawning, they are so unstable that they are likely to be mobilized during high flows, greatly reducing survival of embryos within the gravels. For more details on the effects of suction dredging see Harvey and Lisle (1998).

Harvest. Both illegal harvest of holding adults, as well as legal harvest of fish in the ocean and river fisheries, can limit the abundance of spawning populations. Holding adults are extremely vulnerable to poaching, although the extent to which poaching affects spring-run Chinook populations is largely undocumented. Because UKTR spring- and fall-run Chinook belong to the same Evolutionarily Significant Unit, they are taken legally in sport and commercial fisheries in the ocean. In 2013, CDFW regulations were as follows:
The Klamath River is "open to Chinook salmon fishing from Jan. 1 through Aug. 14 with a daily bag and possession limit of two salmon. The take of salmon is prohibited on the Klamath River from Iron Gate Dam downstream to Weitchpec from Jan. 1 through Aug. 14."
The Trinity River is "open to Chinook salmon fishing from Jan. 1 through Aug. 31. The daily bag and possession limit is two Chinook salmon. The take of salmon is prohibited from the confluence of the South Fork Trinity River downstream to the confluence of the Klamath River from Jan. 1 through Aug. 31." September 1 to December 31, a fall-run Chinook quota is in place, with a four fish limit, only three of which can be over 22 inches. All tributary waters along the main rivers are closed to fishing. These regulations provide some, but not full, protection from harvest pressures on spring-run Chinook, so recreational angling has the potential to limit the abundance of already small spring-run Chinook populations.

Hatcheries. The Trinity River Hatchery, below Lewiston Dam, is the only remaining hatchery in the Klamath basin that still cultures spring-run Chinook salmon. The impacts of hatchery propagation on wild spring-run Chinook salmon in the Trinity basin may be substantial; however, mixed runs of wild and hatchery-reared fish tend to segregate themselves above Cave Junction, with most hatchery fishes returning to TRH. Consequently, most naturally spawning fish are considered to be of wild origin (W. Sinnen, CDFW, pers. comm. 2013). Artificial selection in a hatchery environment has been demonstrated to reduce fitness in fish reproducing in the wild (Araki et al. 2007, 2009). Hatchery-reared spring-run Chinook are also more likely to hybridize with fall-run Chinook because of shifts in run timing and increased rates of straying of both spring- and fall-run fish.

Recreation. Spring-run Chinook may be absent from many suitable areas because of repeated disturbance by humans. Gold dredgers, swimmers, and boaters may stress and displace fish, particularly holding adults (P. B. Moyle and R. Quiñones pers. obsv. 2000). Displacement from suitable habitats may make spring-run Chinook less able to survive natural periods of stress (e.g., high temperatures), or survive to spawning. Increased and unnatural movements of fish make them more noticeable, potentially increasing the incidence of poaching. Not surprisingly, spring-run Chinook tend to persist mostly in the most remote canyons in their watersheds.

Effects of Climate Change: UKTR spring-run Chinook have declined from being the most abundant run in the Klamath-Trinity system to one that is in danger of extinction. Climate change is predicted to lead to decreased snow pack (reduced instream flows), increased water temperatures and more variable flow fluctuations in many portions of their range. For example, the Salmon River already reaches summer temperatures of 21-23°C, approaching lethal temperature thresholds for salmonids. A 1-2°C increase in stream temperatures could greatly

reduce the amount of suitable habitat available for spring-run Chinook and interfere with spawning and recruitment success. Reduced reservoir recharge may limit thermal stratification and the amount of cold water pool available for environmental flows via dam releases, which may be particularly acute in the Klamath River given the extensive network of dams. Climate change is also predicted to increase the frequency and intensity of both drought and flashy floods, both of which will likely limit spring-run Chinook abundance.

Climate change may also increase the incidence of disease outbreaks, due to warmer water temperatures, and lead to increased stress of adult salmon. For example, warmer temperatures favor epizootic outbreaks of *Ichthyophthirius multifiliis* and transmission of the bacteria *Columnaris*. Columnaris disease is associated with pre-spawn mortality of spring-run Chinook that are exposed to above-optimal water temperatures. Increased base flows likely reduce pathogen transmission risk during Chinook salmon migrations (Strange 2007), thus the predicted impacts from climate change (e.g., lower flows, warmer water temperatures, reduced availability of suitable habitats and corresponding increased densities of spawning adults or out-migrating juveniles) may enhance conditions favorable to disease outbreak. Moyle et al. (2013) rated the UKTR spring-run Chinook salmon as "critical vulnerability" to extinction because of the added effects of climate change on already diminished populations.

Status Determination Score = 1.7 - Critical Concern (see Methods section Table 2). The principal self-sustaining wild populations of UKTR spring-run Chinook exist in the Salmon and South Fork Trinity rivers; most other populations are small in number, influenced or supported by hatchery fish, and may not be self-sustaining. Upper Klamath-Trinity rivers spring-run Chinook are considered a Sensitive Species by the USDA Forest Service.

Metric	Score	Justification
Area occupied	2	Only Salmon River and South Fork Trinity River support wild, self-sustaining populations
Estimated adult abundance	2	Only a few hundred natural spawners support the population, with attendant impacts of small populations and hatchery influence
Intervention dependence	3	Hatchery stocks appear to be maintaining the run in the mainstem Trinity; dam removals in Klamath system needed to restore access to historic range; runs dependent upon dam flow releases
Tolerance	2	Narrow temperature tolerance (<20ºC) during holding and spawning migrations; temperatures and other factors in summer holding areas limit suitable habitat
Genetic risk	1	Hybridization with fall-run and/or hatchery spring-run is occurring in some watersheds; fitness reduction may result from hybridization with hatchery stocks
Climate change	1	Increased temperatures, reduction in suitable habitats, increased density of adults and juveniles, and potential increase of disease outbreaks will further limit populations
Anthropogenic threats	1	See Table 1
Average	1.7	12/7
Certainty (1-4)	3	Fairly well studied

Table 2. Metrics for determining the status of UKTR spring-run Chinook salmon, where 1 is a major negative factor contributing to status, 5 is a factor with no or positive effects on status, and 2-4 are intermediate values. See methods section for further explanation.

Management Recommendations: Monitoring of spring-run Chinook occurs annually throughout the Klamath-Trinity system. However, data collected need to be standardized so that trend analyses can be performed. Data from existing surveys demonstrate that suitable habitat exists for adult holding and spawning, yet spring-run Chinook abundance, while showing an upward trend, continues to fluctuate at low numbers (Quinones et al. 2013). Over-summering behavior and associated habitat requirements are the most distinctive life history attributes of spring-run Chinook. The rarity of cool water refuges throughout the UKTR Chinook ESU range is already a significant threat to spring-run Chinook persistence. Spring-run Chinook may be particularly susceptible to warming trends, especially in the face of predicted climate change impacts. As such, reconnecting historic habitats in the upper watersheds of the Klamath and

Trinity rivers and their tributaries to lower main stem river habitats below major dams is necessary for long-term persistence of this run. Such restoration efforts would increase habitat availability for spring-run Chinook and remove barriers, which negatively impact water quality and quantity. UKTR spring-run Chinook are a good indicator species, due to their narrow tolerances to water quality and temperature, as well as their presence during some of the most challenging portions of the year for riverine habitation. The near extirpation of this sentinel species in the Klamath River subbasin indicates that other anadromous stocks that rely on freshwater habitats during their juvenile and adult life histories may also be at risk. Specific management recommendations for spring-run Chinook salmon in the Klamath and Trinity basins include:

- Remove dams on the mainstem Klamath to allow access to historic upstream spawning and rearing areas. Of all salmonids in this drainage, spring-run Chinook would likely benefit the most from increased access to cold-water habitats.
- Restore the Shasta River as a cold-water refuge for all salmonids in the Klamath basin by recapturing spring flows in the river, reducing ground water extraction and, possibly, removing Dwinnell Dam.
- Manage the Salmon River as a spring-run Chinook and summer steelhead refuge by restricting extractive resource use of the river in summer (e.g., continue moratorium on suction dredging).
- Develop a program to investigate impact(s) of the TRH on spring-run Chinook populations (e.g., number of hatchery-reared fishes spawning in the wild, genetic shifts in population) and manage hatchery production accordingly.
- Develop restoration actions and priorities for reducing the impacts of sediment inputs from roads, logging and other activities into rivers of the Klamath-Trinity system, especially on public lands.
- Determine the harvest rate of sport, commercial and traditional fisheries on UKTR spring-run Chinook to improve fisheries management.
- Limit harvest to a mark-selected, in-river, fishery for TRH-produced spring-run Chinook.

Figure 2. Distribution of upper Klamath-Trinity rivers spring-run Chinook salmon, *Oncorhynchus tshawytscha*, in California.