SOUTHERN OREGON – NORTHERN CALIFORNIA COASTAL CHINOOK SALMON
Oncorhynchus tshawytscha

Status: Moderate Concern. Distribution of Southern Oregon - Northern California Coastal (SONCC) Chinook salmon in California is limited to a few watersheds. Their status is threatened by interactions with hatchery stocks, habitat degradation (especially estuary alteration) and fisheries harvest.

Description: Chinook salmon can be distinguished from other salmon species by the many black spots on their back, dorsal fins and both lobes of the caudal fin, as well as by the dark pigment along gums in the lower jaw. Morphological characteristics of SONCC Chinook salmon are as follows: fin ray counts are 10-14 (dorsal fin), 14-19 (pectoral fin), 10-11 (pelvic fin), and 13-16 (anal fin) (Snyder 1931, Schreck et al. 1986). Scales along the lateral line number 131-147. They are also characterized by 93-193 pyloric caeca, 13-18 branchiostegal rays and rough, widely-spaced gill rakers, 12-13 of which are on the lower half of the first gill arch.

Adult lengths can be greater than 140 cm SL but usually fall between 75 and 80 cm SL. Adult Klamath River Chinook salmon are considered to be among the smallest of the Chinook salmon found in the Pacific Northwest and, when compared to Sacramento River Chinook of the same length, are more rounded and heavier (Snyder 1931). Adult Chinook salmon in California can reach weights of 38.6 kg, but average between 9-10 kg. Sexually mature adults are uniformly colored in dark burgundy or olive brown. Males develop humped backs and hooked jaws and are usually darker than females. Chinook juveniles have 6-12 parr marks equal in width or wider than the spaces between them and an adipose fin with dark coloration along the upper edge only although some parr develop spots on the dorsal fin as they grow, most have clear dorsal fins.

Taxonomic Relationships: The SONCC Chinook salmon ESU is distinguished from other ESUs based on genetic analyses. Analysis of microsatellite loci and older allozyme datasets designated Chinook from the Klamath River and Blue Creek (lower Klamath River) into two clusters within the Klamath basin (Myers et al. 1998). The SONCC Chinook salmon ESU contained genotypes from Blue Creek, which clustered with those from streams north of the Klamath River, including southern Oregon, based on microsatellite DNA. Southern Oregon - Northern California Coastal Chinook salmon from the Smith River and Blue Creek also share morphological traits and age of reproductive maturity (Snyder 1931). In Blue Creek, there is also a late fall-run which seems to be segregated from other fish (Gale et al. 1998). Although spring-run Chinook return to the Smith River, the relationship between these and fall-run SONCC Chinook is not well understood. Myers et al. (1998) regard the few spring-run Chinook in SONCC Chinook streams to be part of the ESU.

Life History: Most SONCC Chinook spawning adults migrate into rivers in the late fall, when increases in stream flow facilitate access into Klamath Mountain Province streams. Adults enter tributaries of the lower Klamath River from September through December and spawning occurs in the latter part of this period and into January (Leidy and Leidy

1984). In the Smith River, spawning typically occurs between October and February. Chinook salmon enter Blue Creek in September and spawning peaks after fall rains, usually in November (Gale et al. 1998). However, pulses of spawning fish continued to enter Blue Creek through December, perhaps reflecting differences in reproductive maturity between earlier and later arrivals (Gale et al. 1998). Differences in reproductive behavior were observed for females in Smith River tributaries. The amount of time that a female spent on a redd decreased from 10-21 days to 5-10 days as the spawning season progressed (Waldvogel 2006). Spawners in Blue Creek are primarily 3 years old with a few age 4 and age 5 fish; in addition there are a few grilse, reproductively mature age 2 fish (Gale et al. 1998). In Mill Creek, from 1993-2002, most spawners were 3 year old fish (62%) but, from 1981-1992, 4 year old females comprised the majority of spawners (66%) (Waldvogel 2006).

Chinook salmon fry emerge in lower Klamath tributaries from February through mid-April and most migrate into the ocean in the same year (Leidy and Leidy 1984). In 1995-96, fry outmigration from Blue Creek began before mid-March, peaked in late April and late May, and continued into August (Gale et al. 1998). Fry grew to 103 mm FL throughout the period of outmigration (Gale et al. 1998). Early outmigrants traveled quickly into the estuary. However, larger juveniles can spend months rearing in fresh water before beginning outmigration (Sullivan 1989). In the Smith River, juvenile Chinook were most commonly observed in low salinity zones (<5%) in the upper estuary and were associated with abundant cover from overhanging riparian vegetation (Quiñones and Mulligan 2005). Ocean survival is likely enhanced by longer periods of rearing in fresh water. Of the juvenile outmigrants from Blue Creek in 1996, 28% reared extensively in freshwater. Approximately 5% of the juveniles rearing in Hurdygurdy Creek (Smith River) in 1987 and 1988 remained in the stream to rear after spring flows receded (McCain 1994). However, high flows in the spring of 1988 likely shortened the length of freshwater residency in that year. Juvenile Chinook salmon in tributaries of the Sixes River, Oregon, (northern range of SONCC Chinook) also displayed varying degrees of freshwater residency; some moved into the ocean within weeks of emergence, while others reared in freshwater from two months to more than one year (Reimers 1971). Scale aging revealed that most adults returning to spawn had reared in freshwater for two to six months as juveniles (Reimers 1971). Once in the ocean, Chinook seem to follow defined migration routes but can alter migration patterns to use regions with temperatures of 8°-12°C (Hinke et al. 2005).

Habitat Requirements: Spawning habitats are characterized by large cobbles and sufficient flows to facilitate oxygen delivery to developing embryos. Most SONCC Chinook salmon spawn in the middle reaches of coastal tributaries, but in the Smith River small tributaries are also commonly used for spawning. In Blue Creek, holding spawners favored deep pools and areas with runs and pocket water with fast flows (Gale et al. 1998). Adults have been observed spawning at depths ranging from a few centimeters to several meters, with water velocities of 15-190 cm/sec; however, preferred spawning habitat was at depths between 25 to 100 cm, with water velocities from 30 to 80 cm/sec. Embryo survival is enhanced when water temperatures are between 5°-13°C and oxygen levels close to saturation (Healey 1991). Water temperature requirements of Chinook salmon are discussed in Moyle et al. (2008).

Embryos incubating in optimal conditions generally hatch within 40-60 days, but remain in the gravel as alevins for an additional 4-6 weeks, usually until the yolk sac is absorbed. Juveniles will continue to rear in streams throughout the summer if water temperatures remain <20°C (Gale et al. 1998). Rearing habitats are characterized by shallow water in areas with overhanging riparian vegetation that provides cover, food and habitat complexity.

Distribution: Southern Oregon - Northern California Coastal Chinook salmon are found in streams from Cape Blanco, OR (south of the Elk River) south to the Klamath River, including Klamath River tributaries from the mouth to the Trinity River confluence. In California, SONCC Chinook salmon were found historically in the many small tributaries of the lower Klamath River that are within the ocean-influenced fog belt (USFWS 1979). In 1977 and 1978, SONCC Coastal Chinook were found in Hunter, Terwer, McGarvey, Tarup, Omagar, Blue, Surpur, Tectah, Johnson, Mettah, and Pine creeks (USFWS 1979). In 2000, they were also found in Hoppaw, Saugep, Waukell, Bear, Pecwan, and Roaches creeks, but not in Omagar and Surpur creeks (Gale and Randolph 2000). Chinook salmon from the Rogue and Smith rivers have different ocean migration patterns than Chinook salmon in ESUs to the south (Gale et al. 1998), with a greater tendency for adults in the ocean to stay north of Cape Blanco (Brodeur et al. 2004). Klamath River Chinook salmon stocks tend to associate with the California Current further south.

Trends in Abundance: Southern Oregon - Northern California Coastal Chinook in California are currently found in only a few, small lower Klamath tributaries, including Blue Creek, as well as the Smith River. The abundance of the fall-run appears stable, although populations in the Klamath basin have been adversely affected by land use practices, particularly logging. Spring-run Chinook salmon appear to have largely disappeared from this ESU (Moyle 2002). The majority of SONCC Chinook salmon originate from the Rogue River in Oregon. Individuals from the lower Klamath River tributaries and Smith River contribute to the population to a lesser extent. Historically, some 2,000 – 3,000 adult Chinook salmon spawned in the lower Klamath River each year (Moyle 2002). In 1960, an estimated 4,000 Chinook salmon spawned in lower Klamath tributaries (USFWS 1979) while, in 1978-79, the number of spawners dropped to 500 (USFWS 1979). However, there is considerable natural variability in the number of spawners observed from year to year. In 1995 and 1996, respectively, 236 and 807 fall Chinook salmon were observed in Blue Creek (Gale et al. 1998). A study of Chinook salmon spawning in Blue Creek indicated that surveys observed about half the actual number of spawners, with spawner estimates in survey years (1995- 2009) ranging from 100-2400 fish (Antonetti 2009). The numbers of late fall-run Chinook spawning in Blue Creek from 1988 to 2009 showed an increasing trend (Quiñones at al. 2014 a,b). However, the time series also showed a significant correlation to hatchery returns, suggesting that numbers are supplemented by hatchery strays or that hatchery fish encounter similar ocean conditions as naturally produced fish of the same cohort. Annual numbers of adult Chinook salmon in the Smith River are estimated to range from 15,000 - 30,000 fish (Moyle 2002), but robust population estimates have not been established. There is no evidence of a decline in fall-run spawner abundance in the Smith River. The

numbers of spring-run Chinook adult in the Smith River were probably always low, with 0-21 fish counted in recent years (34 to 53 miles surveyed) (Reedy 2005).

Nature and Degree of Threats: Although poorly documented, SONCC Chinook salmon abundance in California appears to be mostly limited by habitat alteration, hatcheries and fisheries harvest.

Dams. The Smith River is undammed but, in the Klamath River, flow regulation by mainstem dams may affect migration timing and health of adults in the main-stem river prior to entering smaller tributaries. These dams may also negatively affect juveniles outmigrating from the system by reducing peaks of freshets or pulse flows after storm events. In addition, flows regulated by dams in the Klamath River main-stem can also adversely affect migrating Chinook salmon through exposure to high water temperatures that increase the incidence of disease (Belchik et al. 2004).

Agriculture. In the Smith River estuary, construction of dikes and reclamation of lands for agriculture and grazing have reduced the amount of juvenile rearing habitat by more than 40% (R. Quinones, pers. observations, 2007). Diversions of water for flower bulb cultivation, alfalfa production and other purposes in the Smith River drainage may affect salmon outmigration, depending on seasonal timing and volume of water diversions.

Grazing. Grazing of riparian areas by feral cattle has been identified as significant cause of habitat degradation in Blue Creek drainage, causing stream bank sloughing and reduced riparian vegetation (Beesley and Fiori 2008). Cattle grazing along the Smith River estuary has also degraded stream banks and reduced or eliminated riparian vegetation (R. Quinones, pers. observation, 1997-2002).

Transportation. Roads, including highways, have been identified as a major source of habitat loss in SONCC Chinook streams. However, road building is intimately associated with logging in the Klamath Mountains; see below.

Logging. The coastal watersheds of northern California have been heavily logged, beginning in the mid-19th century (USFWS 1979). Logging has altered most coastal streams by increasing solar input and water temperatures through reduced tree canopy cover, introduction of heavy loads of fine sediments that bury spawning gravels and fill pools, and increased surface runoff of precipitation, leading to increased frequency of flash flooding in streams. In many streams, extensive networks of logging roads (mostly unimproved) in north coastal drainages have blocked salmon spawning migrations. Improperly built stream crossings (culverts, bridges and other structures) have created fish passage barriers, impeding fish passage although, in recent decades, many passage impediments have been rectified. Road construction in lower Blue Creek has altered stream morphology and reduced recruitment of large woody debris into the stream channel (Beesley and Fiori 2008). Roads have increased fine sediment delivery to streams in the Smith River basin (Six Rivers National Forest 2011).

Fire. Most lower Klamath and Smith River tributaries are within the marine fog belt, with cooler temperatures and higher fuel moisture that inhibit wildfires; however, in recent years, inland portions of the Smith River watershed have suffered catastrophic wild fires (e.g., Biscuit Fire in 2002) that can potentially degrade main stem habitats.

	Rating	Explanation
Major dams	Low	No dams on the Smith River but dams on Klamath River may affect migration patterns and reduce habitat suitability
Agriculture	Low	Agriculture is a primary land use in the Smith River estuary; estuary alteration from wetland reclamation, diking, diversions, pollutant and pesticide inputs; however, potential effects have not been studied
Grazing	Medium	Cattle grazing in the Smith River estuary has contributed to habitat degradation; cattle grazing in the Blue Creek drainage has substantially impacted riparian and aquatic habitats
Rural residential	Medium	Rural development is increasing in north coastal California watersheds, contributing to habitat degradation, water diversion, and pollutant inputs into streams
Urbanization	n/a	
Instream mining	n/a	
Mining	n/a	
Transportation	Medium	Roads are primary sources of sediment inputs in SONCC watersheds
Logging	Medium	Most watersheds have been heavily logged in the past; legacy effects remain in many watersheds
Fire	Low	Predicted increases in severe wildfires may lead to increased habitat degradation, especially outside the fog belt
Estuary alteration	Medium	Land reclamation for agriculture in the Smith River estuary has reduced juvenile rearing habitats
Recreation	Low	Most habitats are in smaller tributaries not heavily used by swimmers and boaters
Harvest	Medium	Harvest has presumably reduced Chinook numbers to a fraction of historic numbers
Hatcheries	Medium	Hatchery fish probably have negative effects on Klamath River populations but impacts to the main population in the Smith River are likely minimal
Alien species	Low	Few alien species are reported for the Klamath and Smith rivers

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of SONCC 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 unlikely as a result; and a factor rated "no" has no known negative impact to the taxon under consideration. Certainty of these judgments is moderate. See methods section for descriptions of the factors and explanation of the rating protocol.

Estuary alteration. As discussed under agriculture, the capacity of the Smith River estuary to support juvenile salmon rearing has been greatly reduced due to prevailing land uses and associated habitat degradation.

Harvest. Commercial, sport, and tribal fisheries have likely already reduced SONCC Chinook salmon abundance in the past. However, recent regulations to protect Upper Klamath-Trinity fall-run Chinook from overharvest (e.g., closure of fishery in 2006 by Pacific Fisheries Management Council) may have reduced harvest rates of SONCC Chinook salmon from the lower Klamath and Smith rivers in recent years.

Hatcheries. Although hatcheries are not operated in tributaries to the lower Klamath River, SONCC Chinook in the basin are likely interacting with salmon produced by hatcheries located upstream on the main-stem Klamath (Iron Gate Hatchery) and Trinity (Trinity River Hatchery) rivers. Hatchery-produced juvenile Chinook salmon migrate through the middle Klamath River in late summer (USFWS 2001), around the same time that wild SONCC Chinook are also outmigrating. Hatchery-produced adults may stray into lower Klamath tributaries, perhaps interbreeding with and altering the genetic makeup of, wild SONCC Chinook salmon. The abundance of adult Chinook salmon returning to Blue Creek was found to be significantly correlated with returns of adult Chinook salmon to Trinity River Hatchery, suggesting that hatchery strays are contributing to the population (Quiñones 2013). In the Smith River basin, about 50 female Chinook salmon are spawned each year by Rowdy Creek Hatchery juveniles are released in the spring and have been observed displacing other salmonids (e.g., steelhead trout) from estuarine habitats (Quiñones, personal observations, 1997-2001).

Effects of Climate Change: Predicted climate change impacts to north coastal streams are expected to be less than those to inland waters in California, since the maritime climate and associated fog belt will likely offset air temperature increases. However, coastal areas have already experienced a 33% reduction in fog frequency since the early 20^{th} century and further reduction is predicted to increase summer drought frequency and duration along the west coast (Johnstone and Dawson 2010). Predicted increases in air temperatures (up to 10°C by 2100; Dettinger 2005), in combination with reduced fog frequency and associated increases in evapotranspiration, may negatively impact juvenile rearing habitats decrease (e.g., warmer water temperatures, lower flows). Poor ocean conditions (e.g., reduced upwelling, higher temperatures), may also reduce ocean survival and limit gene flow between more northern populations. In addition, sea level rise will likely reduce rearing habitats in estuaries, unless similar habitats become available in upstream areas as estuaries 'back upstream' as a result of sea level rise. Moyle et al. (2013) rated the SONCC Chinook salmon ESU "critically vulnerable" to extinction in 100 years due to the added impacts of climate change, although uncertainty in this regard is high.

Status Determination Score = 3.3 - Moderate Concern (see Table 2 and Methods section). The SONCC Chinook salmon ESU in California is limited to a few watersheds that are impaired, to varying degrees, by habitat degradation associated with land and water use practices (Table 1). This ESU was determined by NMFS on September 16, 1999 to not warrant listing under the Federal Endangered Species Act, although SONCC

Chinook salmon is considered a Sensitive Species by the US Forest Service, Pacific Southwest Region.

Metric	Score	Justification
Area occupied	4	Blue Creek and Smith River are the principal populations, along with smaller populations in tributaries
Estimated adult abundance	3	No systematic surveys have been performed but between 5,000 and 50,000 spawners in the Smith is probable in most years; <1000 spawners in Klamath River tributaries annually
Intervention dependence	4	California populations are largely self-sustaining but some supplementation by hatcheries is likely
Tolerance	3	Multiple juvenile life histories and spawner age diversity demonstrate physiological tolerances
Genetic risk	3	Limited hatchery operations in California portion of range but some concern for hybridization with hatchery 'strays' from other ESUs
Climate change	3	Fall-run is least vulnerable to climate change in north coastal streams of California, since they spawn later in the year and scouring of redds is less likely to influence juveniles; possible sea level rise may negatively affect important rearing habitats in estuaries; Smith River likely to retain runs under worst-case scenarios through end of the century
Anthropogenic threats	3	Multiple threats rated as "medium" (Table 1)
Average	3.3	23/7
Certainty (1-4)	2	Least studied of Klamath River Chinook runs

Table 2. Metrics for determining the status of SONCC 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: The persistence of the two largest populations of SONCC Chinook salmon (in Smith River and Blue Creek in the lower Klamath River) suggests that conservation of this ESU within California is largely reliant upon protection of spawning and rearing habitats in these two watersheds. Increased protection of these populations would also facilitate recolonization of other degraded streams in the ESU, as habitats recover and are restored, potentially expanding the distribution and increasing the abundance of SONCC Chinook salmon.

It has been shown that interactions of wild Pacific salmon with hatchery-produced conspecifics can reduce both the overall fitness of a population (Araki et al. 2008) and its local adaptability (Reisenbichler and Rubin 1999). To determine the status of Chinook salmon within this ESU, both population monitoring and genetic studies are needed to

determine levels of introgression between wild and hatchery stocks and to determine the status of spring-run Chinook salmon within this ESU. Such studies may be of particular value in the Smith River drainage (the largest free-flowing river system in the state) which has been designated a National Recreation Area, and is included in the National Wild and Scenic River program. These designations imply that priority should be given to maintaining self-sustaining, wild populations of native salmonids and other organisms. The introduction of hatchery salmon from Rowdy Creek Hatchery on the Smith River may therefore be in conflict with these designations and also with the status of the Smith River as a 'stronghold' for wild salmon.

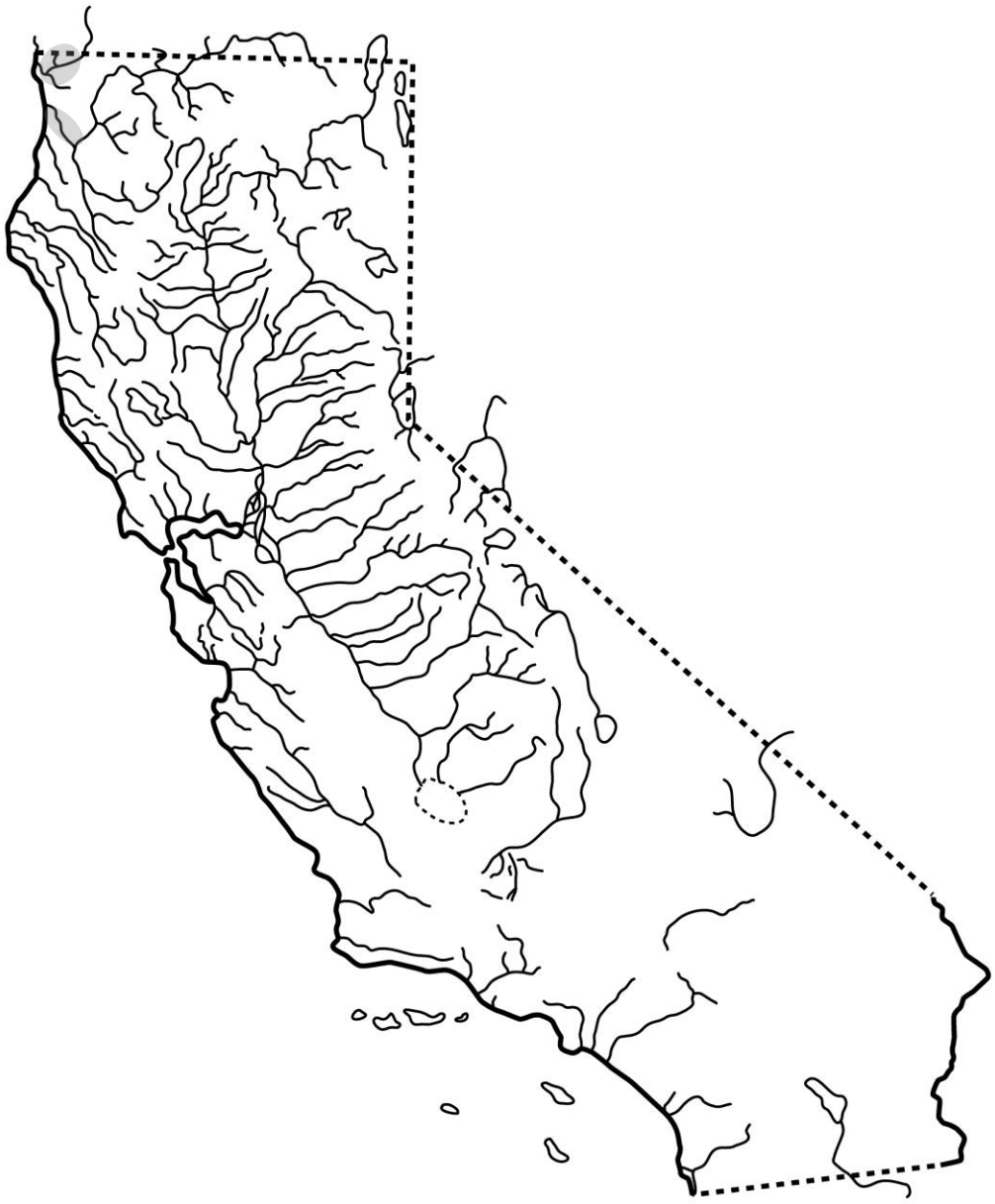

Figure 1. Distribution of Southern Oregon - Northern California Coastal Chinook salmon, *Oncorhynchus tshawytscha*, in California.