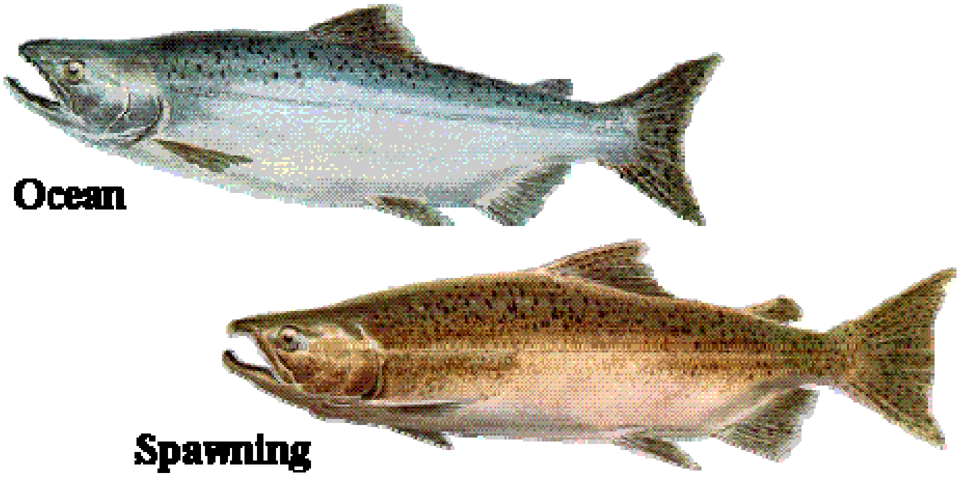
PETITION TO LIST UPPER KLAMATH CHINOOK SALMON (*Oncorhynchus tshawytscha*) AS A THREATENED OR ENDANGERED SPECIES



(US Fish and Wildlife Service)

CENTER FOR BIOLOGICAL DIVERSITY
OREGON WILD
ENVIRONMENTAL PROTECTION INFORMATION CENTER
THE LARCH COMPANY

January 27, 2011

TO: Mr. Gary Locke
Secretary of Commerce
1401 Constitution Avenue, N.W.
Washington, DC 20230

Dear Secretary Locke:

Petitioners Center for Biological Diversity (CBD), Oregon Wild, Environmental Protection Information Center (EPIC) and The Larch Company formally request that the National Marine Fisheries Service list Chinook salmon (*Oncorhynchus tshawytscha*) in the Upper Klamath Basin as a threatened or endangered species under the Endangered Species Act, 16 U.S.C. §§ 1531-1544, under one of the following three alternatives: 1) list spring run Chinook salmon as their own Evolutionary Significant Unit (ESU); 2) list spring run Chinook salmon as a distinct population segment; or 3) list the currently recognized Evolutionary Significant Unit containing both spring and fall run Chinook, based primarily on the severe loss of the spring run from the basin.

Because *O. tshawytscha* is an anadromous salmonid, the National Marine Fisheries Service has jurisdiction over this petition. Petitioners file this petition pursuant to § 553(e) of the Administrative Procedure Act ("APA"), 5 U.S.C. §§ 551-559 and § 1533(b)(3) of the Endangered Species Act, and 50 C.F.R. part 424.14, which grant interested parties the right to petition for issuance of a rule. This petition sets in motion a specific administrative process as defined by § 1533(b)(3) and 50 C.F.R. § 424.14(b), placing mandatory response requirements on the National Marine Fisheries Service.

Petitioners also request the designation of critical habitat for Upper Klamath-Trinity Rivers Chinook salmon (herein referred to "Upper Klamath Chinook") as required by 16 U.S.C. 1533(b)(6)(C), 50 C.F.R. 424.12, and pursuant to the Administrative Procedures Act (5 U.S.C. 553).

The spring run component of the Upper Klamath-Trinity Rivers ESU has seen dramatic declines from historic levels and is in danger of becoming extinct in the foreseeable future. Most known spring run populations have been extirpated and the few runs that do still exist have undergone severe declines, are small in size and many are overrun by hatchery fish, leaving the spring run at immediate risk of extinction. Several human caused and naturally occurring threats have led to the precarious status of spring run Chinook in the Klamath Basin, necessitating their protection under the Endangered Species Act.

Long-term trends for this ESU are unlikely to show improvement in the future without major changes in watershed management. Fall run Chinook have declined from historical numbers of between 125,000 and 250,000 fish returning annually to the Basin. In the past 25 years, wild fish have consistently returned at much lower numbers and only when hatchery fish are included do numbers approach historical estimates in some years. In particular, fall run Chinook have experienced a major downward trend in recent years, especially as a result of the 2002 kill in the lower river. Climate change will lead to even more threatening conditions for this ESU.

The status of the spring run within the current ESU is enough rationale for listing the entire current Upper Klamath and Trinity Rivers ESU under the Endangered Species Act. Protecting the spring run from extinction is essential to maintaining the diversity of the existing ESU.

The Center for Biological Diversity is a nonprofit conservation organization with 320,000 members and online activists dedicated to the protection of endangered species and wild places. http://www.biologicaldiversity.org

Oregon Wild is a nonprofit organization that protects and restores Oregon's wildlands, wildlife and waters. It was founded in 1974 and currently has 7,000 members and supporters. http://www.oregonwild.org

The Environmental Protection Information Center is a community-based, nonprofit organization that works to protect and restore forests, watersheds, coastal estuaries, and native species in Northern California. http://www.wildcalifornia.org

The Larch Company is a for-profit, non-membership conservation organization that represents species who cannot talk and the human generations to come. http://www.andykerr.net/Larch/LarchPT.htm

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Executive Summary

This petition demonstrates that both spring and fall run Chinook salmon (*Oncorhynchus tshawytscha*) in the Upper Klamath-Trinity River Basin (herein referred to as “Upper Klamath Chinook”) warrant protection under the Endangered Species Act. Although wild spawners of both runs have substantially declined, there is particular cause for concern for spring run Chinook salmon, which are near extinction in the Klamath Basin.

Prior to the construction of dams and other habitat modifications, populations of spring run Chinook in the Basin numbered over 100,000 fish. Average escapement for wild spring run Chinook returning to the Klamath-Trinity Basin between 2005-2009 by contrast, was less than 7,000 fish. The Salmon River is considered the remaining viable population of spring run Chinook because it is unaffected by hatchery fish, but recent escapement there has averaged less than a mere 900 fish over the past five years. These numbers highlight the severe decline and precarious status of spring run Chinook. The loss of a unique life history type reduces the ability of the population as a whole to adapt to changing environmental conditions and therefore represents a serious threat to viability.

There is also cause for concern for fall run Chinook salmon in the Klamath Basin with runs increasingly dominated by hatchery reared fish and threats to habitat widespread. In 2002, massive water withdrawals resulting in high temperatures and crowding, led to a major fish kill in which as many as 70,000 Chinook died. This event demonstrated the vulnerability of Chinook salmon to current human-caused and environmental threats.

Overall, both runs of Chinook salmon in the Upper Klamath Basin have undergone severe declines and face many threats, including the presence of impassable dams, which have resulted in the loss of over 300 miles of spawning habitat, massive water withdrawal, logging, mining, livestock grazing, pollution, disease, predation, overfishing, hatcheries, and climate change. In combination, these threats place Upper Klamath Chinook in danger of extinction necessitating protection under the Endangered Species Act (ESA).

The National Marine Fisheries Service (NMFS) has three options for listing Upper Klamath Chinook under the Endangered Species Act: 1) list spring run Chinook as their own evolutionary significant unit (ESU); 2) list spring run Chinook as a distinct population segment (DPS) within the previously recognized Upper Klamath-Trinity River Chinook ESU, or 3) list the entirety of the Upper Klamath-Trinity River Chinook ESU.

In 1998, NMFS included both fall and spring run Chinook in a single ESU. We present new information demonstrating spring and fall run Chinook qualify as separate ESUs based on significant and persistent genetic and reproductive isolation. The spring and fall runs in the Basin are separated by run timing and genetic differences that are comparable to differences between spring and fall runs in California’s Central Valley, which are recognized as separate ESUs. Should NMFS decline to recognize spring and fall runs as separate ESUs, the agency can recognize spring run Chinook as a DPS based on reproductive isolation, genetic differentiation and the unique behavior of the two runs. Finally, should NMFS deny both of these alternatives, it could list the entire Upper Klamath-Trinity River ESU.

I. Description and Systematics

A. Physical Description

Chinook salmon vary in size and age of maturation, with smaller size related to longer distance migration, earlier timing of river entry, and cessation of feeding prior to spawning. Young Chinook, known as fry and fingerlings, are 30-45 mm and 50-120 mm in fork length respectively (Healey 1991). Chinook salmon mature at 30 pounds and 36 inches and are the largest of the Pacific salmon species; many adults exceed 40 pounds. As length corresponds to age, two year-old adults tend to be around 40 centimeters long, and six year-old adults often measure one meter in length (Healey 1991). Klamath River Chinook spawning adults differ from Sacramento River fish in that they are smaller, more rounded, and heavier in proportion to their length (Moyle et al. 2008).

Chinook salmon have a different appearance depending on location and lifecycle. In fresh water, juvenile Chinook are camouflaged by silver flanks with parr marks (darker vertical bars or spots) on the back, dorsal fin, and both lobes of the tail fin. Chinook also have black coloring along the gum line, making the mouth appear black.

Spotting on the caudal fin and the black coloration of their lower jaw make them distinguishable from other sympatric salmonid species (Moyle et al. 2008). Significant differences from Sacramento River Chinook include 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 (Moyle et al. 2008). Klamath River Chinook differ from Columbia River Chinook in their dorsal fin ray, anal fin ray and branchiostegal counts (Moyle et al. 2008).

When juvenile Chinook go through smoltification to prepare physiogically for life in the ocean, they change to a more silvery color and their scales and tails lengthen (Healey 1991). At mature size in the ocean, Chinook develop a darker, blue-green back with silver flanks, black spots on the lobes of the tail and a lighter colored (white) belly, which is typical of open water fish.

When Chinook spawn, their physical appearance changes once again and their silver color turns to a dark maroon, copper, or olive brown. Like other anadromous species, both male and female Chinook have a lowered immune system during spawning. Male Chinook tend to be richer in color than females and develop a hooked jaw and humped back (Allen and Hassler 1986). Upper Klamath-Trinity Rivers spring Chinook salmon enter natal streams as sexually immature adults during the spring season without the breeding colors or elongated kype seen in the fall Chinook salmon (Moyle et al. 2008).

B. Taxonomy

The genus *Oncorhynchus* (order Salmoniformes, family Salmonidae) contains all Pacific salmon of which the Chinook salmon, *Oncorhynchus tshawytscha* grows the largest in size.

The Upper Klamath-Trinity Rivers Chinook salmon ESU is genetically distinguishable from other California Chinook ESUs (Banks et al. 2000, Waples et al. 2004) including the Southern Oregon/Northern California Chinook salmon ESU which spawn downstream of the confluence of the Klamath and Trinity Rivers (Moyle et al. 2008).

The Upper Klamath-Trinity Rivers ESU of Chinook salmon is defined as a distinct unit for purposes of monitoring status and conservation. Within this ESU, two distinct runs are separated by migration timing. While the Upper Klamath-Trinity Rivers ESU does not currently distinguish between spring and fall Chinook, the NMFS biological review team (BRT) acknowledged in its 1998 Status Review of Chinook salmon that there are significant differences between the fall and spring runs in the Klamath River Basin. Likewise, in a recent status review, Moyle et al. (2008) treat the two runs as separate taxa because the spring run represents a life history strategy (or distinct population segment) that is "an essential adaptive component of the ESU and that requires separate management strategies". They note also that historically, fish from the two life histories "were presumably on their own evolutionary trajectories before being derailed by human activities in the basin" (Moyle et al. 2008).

II. Listable entities under the ESA

The petitioners provide three alternatives under which Chinook salmon in the Klamath River Basin qualify as listable entities under the ESA.

A. The Upper Klamath Chinook spring run qualifies as a separate ESU

NMFS could choose to divide the current ESU into a fall run ESU and a spring run ESU, providing ESA protections accordingly, based on the different threat levels for the two runs. According to the National Research Council, "the spring run differs in its life history from other runs and diverges slightly from them genetically as well; it may merit status as a separate ESU (NRC 2004).

A stock must satisfy two criteria to be considered an ESU:

(1) It must be substantially reproductively isolated from other conspecific population units

Insights into the extent of reproductive isolation can be provided by the movements of tagged fish, recolonization rates of other populations, measurements of genetic differences between populations, and evaluations of the efficacy of natural barriers (56 Fed. Reg. 58612, 20 Nov. 1991).

(2) It must represent an important component in the evolutionary legacy of the species.

Evolutionary legacy of a species is the "genetic variability that is a product of past evolutionary events and which represents the reservoir upon which future evolutionary potential depends" (61 Fed. Reg. 4722, 7 Feb 1996). This second criterion for consideration as an ESU is met if the population contributes substantially to the ecological/genetic diversity of the species as a whole.

Relevant questions to evaluating this criterion for the Upper Klamath-Trinity Rivers ESU include: 1) is the population genetically distinct from other conspecific populations; 2) does the population occupy unusual or distinctive habitat; and 3) does the population show evidence of unusual or distinctive adaptation to its environment? (61 Fed. Reg. 4722, 7 Feb. 1996).

In 1998, when the NMFS Biological Review Team (BRT) initially defined the Upper Klamath-Trinity Rivers ESU, it "discussed at some length the proposition that spring and fall run populations should be in separate ESUs based on differences in run-timing and habitat utilization and reproductive isolation" (Myers et al. 1998). Although the majority of the BRT finally decided to include all Upper Klamath and Trinity River Chinook in the same ESU, they acknowledged that the decision was made on limited data and that ESU determination "should be revisited if substantial new information from natural spring run populations becomes available" (Myers et al. 1998). More recent guidance recommends that the Upper Klamath Chinook spring run should be managed separately for conservation purposes: "…the presence of genetic differences and of great differences in life history suggest that it should be managed as a distinct ESU (as was done for the Sacramento River spring run Chinook)" (NRC 2004). Also see Table 1: Summary of Life Cycle and Physiological Differences between spring and Fall Chinook in the Upper Klamath River Basin.

Spring run Chinook salmon qualify as a separate ESU based on their substantial reproductive isolation from fall run Chinook, as well as their importance as components in the evolutionary legacy of the species. The 1998 status review acknowledged that "within the Upper Klamath River Basin, there are statistically significant, but fairly modest, genetic differences between the fall and spring runs" while acknowledging that, "the only estimate of the genetic relationship between spring and fall runs in this ESU is from a comparison of hatchery stocks that may have undergone some introgression during hatchery spawning operations" (Myers et al. 1998). Further studies have occurred since this status review that support dividing the ESU based on run-timing. Banks and Bartron (1999) investigated genetic relationships between spring and fall Chinook salmon populations from the Klamath River. They found that spring run samples have lower mean number of alleles per locus (4.9) than fall run samples (6.1), explaining that this may indicate that the spring run has experienced more extreme reductions in population size and the associated population bottlenecks compared to the fall run. Banks and Bartron (1999) also compare the genetic differences found between spring and fall run Upper Klamath Chinook to those found between runs of fish in California's Central Valley. Branch lengths for clusters involving Klamath River spring and fall samples are similar in magnitude to those connecting Deer and Mill creek spring run samples with late-fall and fall run samples from the Central Valley. In the Central Valley, spring and fall run Chinook are considered to be part of separate ESUs. Because genetic differentiation is scaled similarly in both the Central Valley and Upper Klamath-Trinity Rivers ESUs, the designation of Central Valley spring and fall runs as separate ESUs sets a precedent for the Upper Klamath Chinook runs to also be managed separately.

Furthermore, Kinziger et al. (2008a), analyzed hybridization between spring and fall run Chinook returning to the Trinity River Hatchery (TRH). Their analysis supported the hypothesis that although hybridization does occur between the two runs, the genetic data they collected represented two populations that are separated by run timing. They explain their results by noting that the two runs may differ substantially in their maturation schedule, migratory patterns, and the sections of the river used as spawning habitat and that this frequently results in reproductive isolation. Kinziger et al. report that their data supports the presence of genetically distinct spring and fall run Chinook returning to the TRH based on genetic differences that correlate with run timing. Although hybridization was found to occur in the river, the degree of hybridization, "is far less than would be expected if the two life-history forms had been admixing long enough and successfully enough to produce a hybrid swarm" (Kinziger et al. 2008a). Therefore, spring and fall run Chinook in the Trinity River maintain significant reproductive and genetic isolation despite the hybridization that does occur. These studies provide significant new genetic information so that reevaluation of the ESU is warranted.

Also, it bears noting that historically, spring and fall run Chinook salmon were reproductively isolated with spring run fish spawning upstream early in the season and fall run fish spawning further downstream later in the season. Construction of dams on the Klamath and Trinity Rivers effectively cut off spawning of spring run salmon upstream. In the BRT's decision to list California's Central Valley spring run Chinook salmon, they cited the substantial ecological differences in historical spawning habitat as one of the reasons to list the run as a separate ESU, and the same logic applies to Upper Klamath Chinook salmon.

The Upper Klamath spring run Chinook is both reproductively isolated and representative of an important evolutionary legacy for the species; it should be separated into its own ESU and listed under the ESA according to its status in the Basin.

B. The Upper Klamath Chinook spring run qualifies as a DPS

Should NMFS again decide that the spring run of Chinook salmon in the Upper Klamath River Basin does not qualify as an ESU, NMFS should consider spring run Chinook salmon as a distinct population segment (DPS) within the current evolutionary significant unit (ESU) and list the DPS separately as endangered under the ESA.

The Chinook salmon in the Upper Klamath-Trinity Rivers system includes two significantly different life histories which by logic, traditional practice, and precedent need to be considered and conserved separately from one another. Listing spring run Chinook as a DPS would satisfy the need for protection acknowledged by the National Research Council (2004).

In 2006, NMFS set a precedent for listing a DPS of an ESU when it listed ten DPSs of west coast steelhead. Although anadromous steelhead were not completely reproductively isolated from resident rainbow trout, they qualified as a DPS and warranted listing (71 Fed. Reg. 834, 5 Jan. 2006). The Upper Klamath Chinook spring run also satisfies the criteria for being considered a DPS. The DPS policy requires a population to be both discrete and significant in order to be a listable entity. Under this policy, a population segment is discrete if it satisfies either one of the following criteria:

(1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation. A

population need not have “absolute reproductive isolation” to be recognized as discrete.

(2) It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act. 61 Fed. Reg. 4725.

Furthermore, a population will be considered significant based on, but not limited to, the following factors:

(1) Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon,

(2) Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon,

(3) Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or

(4) Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

The Upper Klamath Chinook spring run is discrete because the run is reproductively and behaviorally separate from the fall run in the Basin. As discussed above, Banks and Bartron (1999) and Kinziger et al. (2008a) present new evidence that suggest significant and persistent genetic and reproductive isolation of the spring run in the Basin. Behavioral isolation is demonstrated by the fact that adult spring run Chinook enter the Basin earlier in their life history to hold for several months in upstream pools. Also see Table 1: Summary of Life Cycle and Physiological Differences between spring and Fall Chinook in the Upper Klamath River Basin. This provides significant behavioral differences that help to qualify spring run Chinook in the Upper Klamath Basin as discrete.

As noted by the National Research Council (2004):

> In addition, the adults typically enter freshwater before their gonads are fully developed and hold in deep pools for 2–4 mo before spawning. In California, this strategy allows salmon to spawn and develop in upstream reaches of tributaries that often are inaccessible to fall run Chinook because of low flows and high temperatures in the lower reaches during fall (Moyle 2002). Major disadvantages of such a life-history pattern in the present system are that low flows and high temperatures during the adult and smolt migration periods can prevent the fish from reaching their destinations or greatly increase mortality during migration (Moyle et al. 1995, Trihey and Associates 1996).

Spring run Chinook in the Upper Klamath Basin are significant based on marked genetic differences, and unique ecological setting. Kinziger et al. (2008b) found that, "the 12 populations of Chinook salmon from Klamath-Trinity Basin exhibited substantial levels of genetic differentiation from one another." The existing genetic differentiation allowed accurate estimates of the proportion of individuals from each population from a sample of unknown composition. Conserving the spring run will help to maintain the genetic diversity of the ESU as a whole, and will make it more resilient to environmental changes and stochastic events.

As discussed above, Kinziger et al. (2008a) analyzed evidence of hybridization between spring and fall run Chinook returning to the Trinity River Hatchery. The genetic differences in spring and fall run Chinook in the Basin which result from the isolation between the runs is further evidence of the significance of spring run Chinook to the viability of the ESU as a whole.

The fact that spring run Chinook enter the river system from the ocean significantly earlier than fall run Chinook and hold in deep cold water pools through the hottest months of the year further illustrates the unique ecological setting that the spring run occupies in the Basin.

By representing a unique life history, spring run fish are significant to the long-term survival of Upper Klamath-Trinity River Chinook. Life history diversity must be maintained in order for Chinook in the Basin to be viable because it provides the population more resilience to environmental variation. Climate change related to anthropogenic emissions of greenhouse gases will expose these fish to environmental changes which will be particularly detrimental should the spring run life history be eliminated from the Basin.

Based on both its discreteness and significance, NMFS would be justified in protecting the Upper Klamath spring Chinook as a DPS under the ESA.

C. The Upper Klamath-Trinity Rivers ESU

The third option for NMFS is to list the entire Upper Klamath-Trinity Rivers ESU, as it is currently defined, as threatened or endangered under the ESA based primarily on the endangered status of its spring run component.

From a biodiversity perspective, the loss of one life history from an ESU with multiple populations is discouraged because of the damage this causes to the ESU as a whole. An Independent Scientific Advisory Board report (ISAB) on the viability of ESUs containing multiple types of populations explains:

> "The available evidence indicates that the loss of one or more life-history types from an ESU can impact abundance and productivity. The effect on ESU diversity and spatial distribution is less speculative; loss of a life history type from an ESU clearly impacts these attributes. The ISAB concludes that the maintenance (or restoration, where possible) of all of the naturally occurring life history types of an ESU should be one of the goals of salmon recovery" (Bilby et al. 2005).

Specifically referring to the role of diverse run-timings in an ESU, the ISAB explains that run timing is “an important life history strategy linked to the environment and local adaptation,” and suggests the maintenance of populations of different run-times is a reasonable factor to consider in listing Chinook salmon ESUs (Bilby et al. 2005).

Studies of the genetic structure and variation of Upper Klamath Chinook salmon also indicate how important it is to maintain all existing populations to ensure long-term genetic viability of the ESU. Studies have indicated that each stock in the Klamath Basin is genetically distinct and therefore contribute to the genetic viability of the species. Banks and Bartron (1999) documented substantial heterogeneity among Klamath River Chinook stocks. As described above, Kinziger et al. (2008b) also found substantial genetic variation between Chinook salmon stocks in the Klamath Basin: “Despite the rather extensive history of out-of-basin transplantation within the Klamath-Trinity basin, Chinook salmon within the basin have retained a substantial degree of genetic structure” (Kinziger et al. 2008b). This diversity, especially that of the endangered spring run, must be maintained for the viability of the entire ESU. The importance of the spring run to the viability of the ESU as a whole is enough to justify listing the entire Upper Klamath-Trinity Rivers ESU under the ESA.

In conclusion, several options exist for listing the spring run Chinook of the current Upper Klamath-Trinity Rivers ESU under the ESA including listing the entire ESU as it is currently described. The current management of the entire ESU as un-threatened, however, is based on limited and obsolete information, and must be reconsidered in response to this petition.

III. Ecology and Biology of Upper Klamath Chinook salmon

A. Life cycle and Physiology

The Chinook salmon life cycle begins when an adult female prepares a nest, called a “redd,” by digging in a stream area with suitable gravel type, water depth and water speed (McCullough 1999). Body size, which is related to age, may be an important factor in migration and redd construction success. All Chinook salmon tend to use spawning sites with large gravel and significant water flow through the gravel. Deep water with sufficient sub-gravel flow is essential to provide oxygen to the eggs and remove metabolic waste. Thus, limited sub-gravel flow resulting in low oxygen concentrations are linked to egg mortality (Allen and Hassler 1986). Excess silt in the water can also block water flow through gravel (Healey 1991).

Female Chinook lay 2,000 to 17,000 eggs, each about nine millimeters in diameter (Healey 1991). One or more males then release sperm into the redd before females cover it with gravel (Allen and Hassler 1986). Once the eggs have been fertilized, adult Chinook guard the nest briefly (up to a month) before dying. Egg mortality can result from limited oxygenation, extreme temperatures, predation and toxic chemicals (Healey 1991). Depending on water temperature, the eggs will hatch three to five months after being laid, which ensures young salmon (termed “alevins”) emerge when river conditions are best.

Alevins remain in the spawning habitat for at least two to four weeks until their yolk sacs are completely used. Like the eggs, Alevins require adequate water flow through the gravel for growth and survival (Nawa and Frissell 1993). Once the alevin consumes its yolk sac, it enters the fry-fingerling stage and begins feeding and socializing. Some fry remain in the spawning grounds, while others begin their tail-first migration to the ocean soon after emerging from the redd. A number of factors such as water flow, food availability, temperature and competition may influence when the fry and fingerlings migrate.

The vast majority of juvenile fall Chinook migrate within one year of hatching whereas the majority of spring Chinook migrate after one year. Moyle et al. (2008) reports on a study by Sullivan (1989) which identified three distinct types of juvenile freshwater life history strategies for UKTR fall Chinook. The majority of fish fall into the first and second categories: 1) rapid migration following emergence, and 2) tributary or cool-water area rearing through the summer and fall migration. A small percentage of fish were in a third category which remained in freshwater through winter and migrated to the estuary as yearlings.

Juvenile Chinook undergo smoltification, a physiological transformation that prepares the fish for the increased salinity in the ocean (Weitkamp 2001). Fall Chinook grow to smolt size near the end of their time in the estuary, whereas spring Chinook turn into large smolts before they reach the estuary (Healey 1991). The amount of time a juvenile salmon spends in freshwater varies. Some male Chinook salmon mature in freshwater while others spend less than a year in freshwater, depending on genetic and environmental factors (NRC 2004). Juvenile fall run Chinook spend less than a year in the fresh water of the Klamath River Basin, allowing the juveniles to avoid unfavorable late summer stream conditions (Healey 1991, Moyle 2002). Spring run Chinook however, spend at least one year in freshwater before migrating to the ocean (Healey 1991).

The majority of spawners returning to the Klamath River Basin are age three fish. This reflects heavy mortality of older and larger fish in ocean fisheries. Some four, five, and six year old fish are found spawning (Moyle et al. 2008). Some fish return from the ocean within two or three months, in the case of a small number of yearling males (called jack salmon). These jack salmon constituted 2-51 percent of the annual Klamath River Chinook salmon numbers between 1978 and 2006 (Game 2006 as cited in Moyle et al. 2008)

In the ocean, Klamath River Chinook salmon are found in the California Current system off the California and Oregon coasts. Moyle et al. (2008) reports that salmon seem to follow predictable ocean migration routes. Chinook recaptured from the Klamath River generally use ocean areas that exhibit temperatures between 8° and 12°C (Hinke et al. 2005). Chinook salmon from the Klamath and Trinity hatcheries were observed in August south of Cape Blanco (Brodeur et al. 2004).

Adult Chinook return to freshwater to spawn and die. During ocean residence, salmon build up stores of body fat and cease feeding during upstream migration. Spring run Chinook, enter the Klamath River between March and July and spawn between late August and September, while fall run Chinook enter the river between July and October and spawn between September and January (Myers et al. 1998).

The timing of upriver migration into freshwater and spawning of Chinook salmon is likely defined by water temperature and flow regimes. For example, data collected primarily from Columbia River migration suggests that spring Chinook migrate at 3.3-13.3ºC and fall Chinook migrate at 10.6-19.4ºC (McCullough 1999).

In general, salmon runs today occur later than they did historically. The current fall run of Chinook occurred earlier and was known as the summer run in the past (Snyder 1931). For example, Moyle et al. (2008) reports that run timing on the Shasta and Klamathon Racks appears to occur one to four weeks later than historic run timing. Although run timing has responded to accommodate warmer stream conditions, temperatures are likely still stressful to migrating salmon and may result in increased mortality of spawning adults (NRC 2004).

Chinook rely primarily on olfaction memory and partially on sight to find their way back to their natal stream. Some evidence suggests that fall run Chinook seem to have a stronger homing instinct than spring Chinook (Healey 1991). Adults primarily migrate during the day, which exposes them to higher temperatures that may inhibit their migration or increase mortality. After spawning, adult females defend their eggs; thereafter both male and female salmon deteriorate rapidly, often developing a fungal disease, and die within 2-4 weeks (Allen and Hassler 1986).

Spring run Chinook

The variation of life history between spring and fall run Chinook is relevant to the difference in status between the runs. Many of these are shown below, in Table 1. Unlike fall Chinook, spring Chinook in the Klamath River Basin utilize streams and tributaries a great deal during their life cycle. Juveniles usually reside in streams for at least one year before migrating to the ocean (Healey 1991). These juveniles are much more dependent on freshwater stream ecosystems because of their extended residence in these areas.

Spring Chinook adults return to the Klamath River between March and July before their gonads have fully developed (Moyle et al. 2008). The majority of late-entry spring Chinook in the Klamath system are of hatchery origin (Barnhardt 1994, NRC 2004). Moyle et al. (2008) note a study which identified adult Trinity River spring Chinook migration continuing until October. They argue however that given this late timing, it is unclear if these fish are sexually mature and able to spawn with spring Chinook adults already in the system. Also, they report, that because this late spring run is limited to the Trinity River, it is possible these fish represent hybrid spring and fall Chinook created by hatchery practices (Moyle et al. 2008).

Spring adults typically hold in deep (greater than two meters) freshwater pools for 2-4 months to allow their gonads to develop before spawning (NRC 2004). These behaviors allow spring Chinook salmon to spawn much further upstream than fall Chinook, who must contend with higher temperatures and lower flows in the lower Klamath during the late summer months (Moyle 2002). Spring Chinook spawning peaks in October.

After emerging from the redds between March and early June, spring run fry remain in the same cold headwaters as holding adults for the summer (West 1991). Some juveniles migrate downstream beginning in October, but most remain in the headwaters until the spring (Trihey and Associates 1996).

Spring run Chinook typically spend more time in freshwater streams, both during their downriver and spawning migrations. They are therefore more vulnerable to adverse stream conditions. The increased time spent in streams and greater distance of migration are disadvantages to survival in the current system because spring Chinook experience low flows and high temperatures during migration that can prevent them from reaching their destinations and significantly increase mortality during migration (Moyle et al. 1995, Trihey and Associates 1996).

Table 1.

Summary of Life Cycle and Physiological Differences between Spring and Fall Chinook in the Upper Klamath River Basin

	Spring Chinook	Fall Chinook	Citations
Adult migration immigration	Between March and July with a peak between May and early June. Spring Chinook migrate before reaching sexual maturity and holdover in deep (greater than two meters) freshwater pools for 2-4 months prior to spawning.	Between mid July and late October. Migration and spawning occur under decreasing temperature regimes.	Barnhart 1994, NRC 2004, Myers et al. 1998, Moyle et al. 2008
Holding elevation	Historically, overlap of spawning areas was rare between spring and fall Chinook because spring Chinook spawned well upstream of fall Chinook before the construction of dams. Spatial separation between the two runs in the Klamath-Trinity system occurs at approximately 1,700 feet	Downstream of 1,700 feet elevation (must contend with higher temperatures and lower flows during migration in the late summer months.	Moyle 2002, Moyle et al. 2008
Spawning	Begins between late August and September, peaks in October.	Between September and January.	Myers et al. 1998, Moyle et al. 2008
Emergence from gravel	Between March and early June, remain in the same cold headwaters as holding adults for the summer.	Late winter or spring, timing dictated by water temperature.	Trihey and Associates 1996, Moyle et al. 2008
Juvenile outmigration	Some juveniles migrate downstream beginning in October, but most remain in the headwaters until the spring.	Most juveniles reside less than one year in fresh water, allowing them to avoid unfavorable late summer stream conditions. Between 1997-2000, wild juveniles were observed in the lower river in the beginning of June with a peak in mid-July.	West 1991, Moyle et al. 2008

B. Diet

Chinook salmon diet varies depending on growth stage. As alevins, the young fish rely on nutrients provided by the yolk sack attached to the body until leaving the redd after a few weeks.

After emerging from the gravel, young fry begin to feed independently. Juveniles feed in streambeds before gaining strength to make the journey to the ocean. During this time, fry feed on terrestrial and aquatic insects and amphipods.

As juveniles migrate toward the ocean, they may spend months in estuarine environments feeding on plankton, small fish, insects, or mollusks. Small fry feed primarily on zooplankton and invertebrates, while larger smolts feed on insects and other small fish (ie: chironomid larvae, chum salmon fry and juvenile herring; Healey 1991).

Juvenile Chinook salmon can feed and grow at continuous temperatures up to 24ºC when food is abundant and conditions are not stressful (Myrick and Cech 2001). In the late summer, juveniles seek out cooler temperatures in refuge pools along the Lower Klamath River, where they may experience intraspecies competition for food.

At sea, where the bulk of feeding and growth is done, adult Chinook typically feed on small marine fish, crustaceans, and mollusks (i.e., squid). Adult Chinook grow quickly in the estuary and gain body mass during their time at sea, building fat reserves that are required for upstream migration and spawning. During the upstream migration, Chinook do not feed and rely on stored energy while traveling hundreds of miles.

C. Associated Fish Species

The Klamath River Basin is home to 19 native fish species, most of which spend part of their lives in the ocean, and 13 nonnative fish species, primarily freshwater fish. Three fish species in the upper Klamath River Basin have been listed under the ESA: the Lost River sucker (*Deltistes luxatus*), the shortnose sucker (*Chasmistes brevirostris*) and Coho salmon (*Oncorhynchus kisutch*) from the Southern Oregon/Northern California Coast (SONCC) ESU (NRC 2004).

D. Habitat Requirements

The variety of habitats Chinook salmon encounter means that they require a number of particular conditions in order to survive and reproduce. Chinook salmon in the Klamath-Trinity River Basin occupy the main stem rivers and tributaries during migration, spawning, and rearing. They also occupy the estuary and open ocean for variable time periods during maturation. Chinook salmon habitat use and requirements are best studied for their time spent in freshwater although ocean conditions are also significant to the survival and viability of these populations.

Migration and Spawning habitat

Upper Klamath Chinook salmon migrate from the open ocean to spawning habitat, typically to the same place where they hatched. During this time, they are in a stressed condition due to their reliance on stored energy to complete the long journey upstream, leaving them highly susceptible to additional environmental stressors. This was clearly a factor during the 2002 fish kill when inadequate stream flows, temperature conditions, and the resultant crowding of fish led to disease outbreaks and mass mortality. Chinook salmon require access to spawning habitat in the main stem rivers and tributaries, cold water, cool pools in which to hold, clean spawning gravel, and particular dissolved oxygen levels, water velocities, and turbidity levels in order to successfully migrate and spawn. Access to spawning habitat is threatened by physical conditions including the existence of impassable dams, which caused the extirpation of several populations of spring run Chinook. Also, the ongoing variability in water flows does not allow Chinook salmon to access certain streams for spawning.

During migration and spawning, low water temperatures are crucial to success of Chinook salmon. Under warm conditions, salmon cease their upstream migration and instead hold in cooler pools. Upper Klamath spring Chinook enter the Klamath estuary during a period when river water temperatures are at or above optimal holding temperatures (Moyle et al. 2008). In June, temperatures in the Lower Klamath River typically rise above 20°C and can be as high as 25°C in August (Moyle et al. 2008). Prior to entering fresh water, Spring Chinook use thermal refuges in the estuarine salt wedge and associated near shore ocean habitat (Strange 2003). Strange (2005) found that when daily water temperatures were on the rise, 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. Optimal adult holding habitat for spring Chinook is characterized by pools or runs greater than one meter 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, presumably the best holding habitats are deep pools with cold water sources, such as those at the mouths of tributaries, or are deep enough to be subject to thermal stratification (Moyle et al. 2008). Upper Klamath fall Chinook salmon enter the Klamath estuary for only a short period prior to spawning. However, unfavorable temperatures can be found in the Klamath estuary and lower river during this period and chronic exposure of migrating adults to temperatures of even 17°-20°C is detrimental (Moyle et al. 2008). Optimal spawning temperatures for Chinook salmon are less than 13°C (McCollough 1991) and fall temperatures are usually within this range in the Trinity River (Quilhillalt 1999). Magneson (2006) reported water temperatures up to 14.5°C during spawner surveys in 2005. The Shasta River historically was the system’s most reliable spawning tributary from a temperature perspective (Snyder 1931), but diversions of cold water have greatly diminished its capacity to support salmon (Moyle et al. 2008).

According to McCullough (1999), adults are more sensitive to higher temperatures than juveniles, as higher temperatures can increase the adults’ metabolic rate and deplete their energy reserves, weaken their immune system, increase exposure to diseases, and prevent migration. Also, temperatures at or above 15.6ºC can increase the onset of diseases (Allen and Hassler 1986). Riparian vegetation is critical as it provides much needed shade to cool the water (Moyle 2002) and creating “thermal refugia” in which fish can escape high temperatures. The presence of cold water in the Basin is threatened by dams, water withdrawals, as well as logging and grazing which decrease riparian vegetation.

Spring run Chinook migrate earlier before their gonads are fully developed and then hold in deep cool pools before spawning. Therefore, the presence of deep cold-water pools is essential to the survival of spring run fish in particular. Dams, water withdrawals, logging, mining, and grazing all contribute to lower water levels in the Basin and threaten the presence of deep pools essential for spring Chinook. Spring Chinook are also more sensitive to high temperatures than fall Chinook (Allen and Hassler 1986).

According to the National Research Council (2004), Migrating adults also need dissolved oxygen levels above five mg/l, deep water (deeper than 24 cm), breaks from high water velocity, and water turbidity below 4,000 ppm (NRC 2004).

Spawning gravel also must be free of excessive sediment such that water flow can bring dissolved oxygen to the eggs and newly hatched fish. With too much sediment, incubating eggs are smothered and reproductive success rate declines significantly. In a study on the Shasta River (Ricker 1997), six out of seven locations, had levels of fine sediment high enough to significantly reduce fry emergence rates and embryo survival. Logging, mining, and grazing increase sediment in Chinook spawning habitat in the Basin. Spawning occurs primarily in habitats with large cobbles loosely imbedded in gravel and with sufficient flows for subsurface infiltration to provide oxygen for developing embryos (Moyle et al. 2008). In a survey of Trinity River Chinook redds, Evenson (2001) found embryo burial depths averaged 22.5-30cm suggesting minimum depths of spawning gravels needed. Regardless of depth, the key to successful spawning is having adequate flows of water (Moyle et al. 2008).

Rearing

During rearing and migration, Chinook require certain temperatures, habitat diversity, and water quality characteristics.

After hatching, juvenile Chinook require rearing habitat before making their migration to the estuary and to the ocean. Ideal fry rearing temperature is estimated at 13ºC and temperatures above 17ºC are linked with increased stress, predation, and disease. High water temperatures can prevent smoltification, an essential process that prepares fish to leave freshwater habitat (McCullough 1999).

Stream temperature during migration is critical, as prolonged exposure to temperatures of 22-24ºC has resulted in high mortality for migrating smolts, and juveniles who transform into smolts above 18ºC may have low survival odds at sea (Baker et al. 1995, Myrick and Cech 2001).Vegetation provides relief from high temperatures, as well as shelter from predators (Moyle 2002). Logging, mining, and grazing all have reduced streamside vegetation in the Basin.

Habitat diversity is important for juvenile Chinook survival, as juveniles face predation by fish and invertebrates, as well as competition for rearing habitat from other salmonids (hatchery Chinook and Steelhead; Healey 1991, Kelsey et al. 2002). Chinook require the correct grades of gravel, the right depths and prevalence of deep pools as well as the existence of large woody debris and the right incidence of riffles (Montgomery et al. 1999). This allows for a variety of habitats which are required by Chinook at different life stages.

Chinook fry may compete for shallow water rearing habitat with hatchery fish and steelhead. Increased river flows mitigate this competition and help Chinook survival by increasing habitat on the river’s edge, where fry (under 50 mm) feed and hide from predators (NRC 2004).

As juvenile Chinook migrate down river, they prefer boulder and rubble substrate, low turbidity and water velocity slower than 30 cms^{-1} (Healey 1991). These conditions allow juveniles to use the faster-moving water in the center of the river for drift feeding, while resting in the slower areas (Trihey and Associates 1996). Smaller fish tend to stay in the slower-moving water near the banks of the river. High water turbidity threatens Chinook (Bash et al 2001) and in the Klamath Basin, logging and grazing both serve to increase turbidity.

Juvenile Chinook require high levels of dissolved oxygen (DO). Low DO levels decrease alevin and fry survival; decrease successful Chinook egg incubation rates; decrease the growth rate for surviving alevins, embryos, and fry; force alevins and juveniles to move to areas with higher DO; and negatively impact the swimming ability of juvenile Chinook (NCWQCB 2010). If DO levels average lower than 3-3.3 mg/L, 50% mortality of juvenile salmonids is likely, while in water above 20˚C, daily minimum DO levels of 2.6 mg/L are required to avoid 50% mortality (NCWQCB 2010). Factors in the Basin which contribute to sub-optimal DO levels include chemical pollution, logging, and dams.

Chinook salmon also require pH levels that are not too high. Even high pH levels which are not directly lethal to salmonids can cause severe harms to Upper Klamath Chinook (NCWQCB 2010), including decreased activity levels, increased stress responses, a decrease or cessation of feeding, and a loss of equilibrium (NCWQCB 2010). The Klamath River's pH in the summer often rises above 8.5, and sometimes reaches 9. At the Miller Island Boat Camp in 2008, the river's pH in early July, measured daily, had several consecutive days with pH values ranging from 9.06-9.53 (USGS 2009, Appendix B). Few studies directly examine the effects of high pH values on Chinook salmon. However, rainbow trout are stressed by pH values above 9 and generally die if the pH value rises above 9.4 (NCWQCB 2010). Nutrient loading of stream systems including those caused by agricultural runoff can lead to higher pH in river systems (NCWQCB 2010).

Once juvenile Chinook reach the estuary, less developed fall run fry remain and seek out the tidal channel where the banks are low, while larger spring run smolts prefer near shore areas near the mouth of the river (Healey 1991). Juveniles change location with the tide as the salinity of the water changes. Larger Chinook smolts seek out deeper pools to avoid light.

Ocean

Once Chinook enter the ocean, most reside at depths of 40-80 meters (Healey 1991). Some research suggests that spring Chinook migrate further offshore, while fall Chinook tend to stay near the shore and close to their river (Allen and Hassler 1986). In the marine environment, Chinook salmon require nutrient-rich, cold waters associated with high productivity and higher rates of salmonid survival. Warm ocean regimes are characterized by lower ocean productivity which can affect salmon by limiting the availability of nutrients regulating the food supply and increasing the competition for food. Climate and atmospheric conditions can affect these conditions (NMFS 1998). In order to survive in the marine environment, Chinook salmon also require favorable predator distribution and abundance. This can be affected by a variety of factors including large scale weather patterns such as El Niño. NMFS (1998) cites several studies which indicate associations between salmon survival during the first few months at sea and factors such as sea surface temperature and salinity.

E. Distribution

Spring and fall run Chinook distributions have been affected differently by conditions in the Basin because spring run Chinook enter freshwater earlier than fall run Chinook, and historically traveled much greater distances upstream (Hamilton et al. 2005).

Spring run Chinook salmon were historically found throughout the Klamath Basin. They used suitable reaches in the larger tributaries such as the Salmon River and, flows permitting, they also accessed smaller tributaries for holding and spawning. They were once especially 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 (Moyle et al. 2008). Spring run Chinook were once also widely distributed throughout the Basin above the current sites of dams, attaining holding and spawning grounds on the Sprague, Williamson and Wood Rivers above Upper Klamath Lake (Moyle et al. 2008). This habitat was blocked below Klamath Falls in 1895 by construction of Copco 1 Dam (Hamilton et al. 2005).The construction of Dwinnell Dam on the Shasta River eliminated access to Upper Klamath spring Chinook habitat in that watershed.

Currently, only the Salmon River, a major freshwater tributary to the Klamath River, maintains a viable population in the Klamath River Basin (Moyle et al. 2008). Approximately 177 km (110 mi) of habitat is accessible to spring Chinook in the Salmon River (West 1991) but most of it is underutilized or unsuitable (Moyle et al. 2008). The South Fork Salmon River holds the majority of the spawning population but smaller tributaries where spring Chinook redds have been found in the Salmon River Basin include Nordheimer, Knownothing, and Methodist Creeks. In addition, there are dwindling populations of spring Chinook in Elk, Indian, Clear, and Wooley Creeks (Moyle et al. 2008).

In the Trinity River Basin, spring Chinook salmon once spawned in the East Fork, Stuart Fork, Coffee Creek, and the main stem Upper Trinity River (Campbell and Moyle 1991). The construction of Lewiston Dam in 1964 blocked access to 56 km of spawning and nursery habitat on the main stem Trinity River (Moffett and Smith 1950).

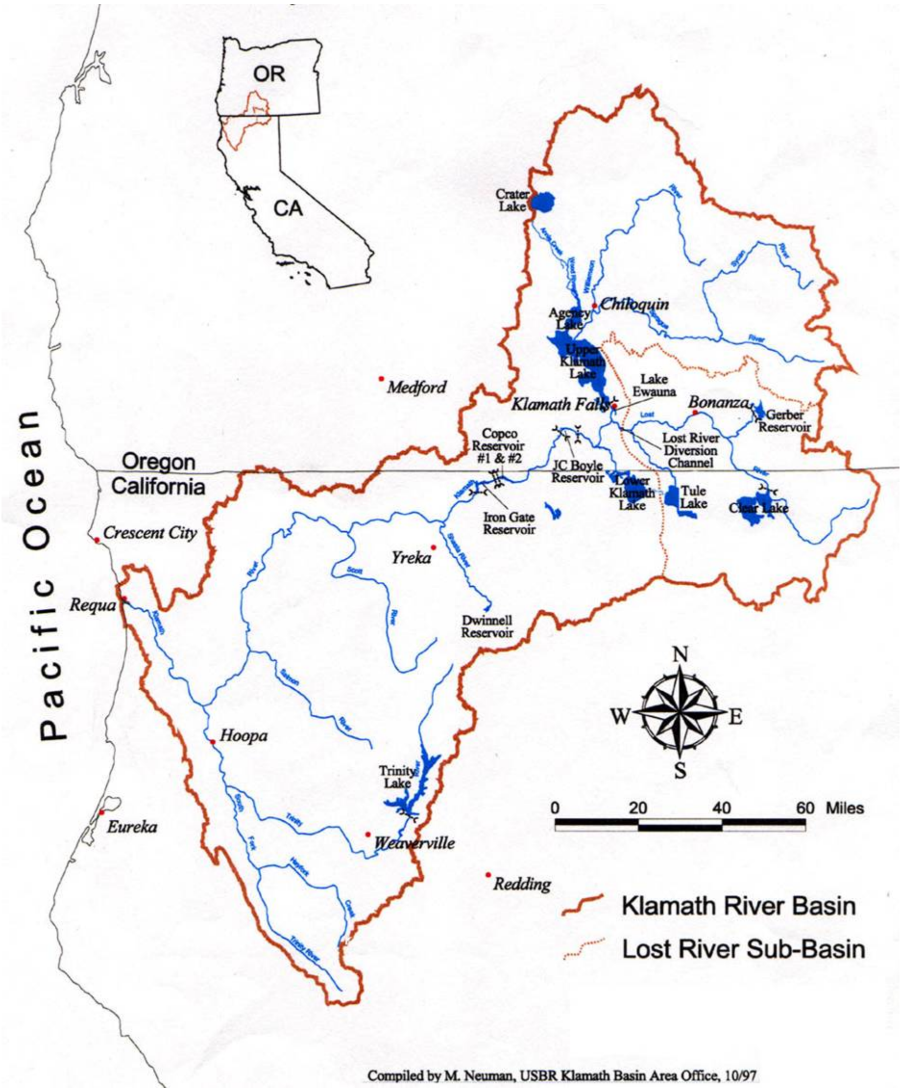
Currently, Trinity River spring Chinook are present in small numbers in Hayfork and Canyon Creek, as well as in the North Fork Trinity, South Fork Trinity and New Rivers (Moyle et al. 2008). The Trinity River Hatchery releases over 1 million juvenile spring run Chinook every year, usually in the first week of June. Apparently, all spawners in the main-stem Trinity River below Lewiston Dam are of hatchery origin (NRC 2004).

The distribution of fall run Upper Klamath Chinook has been less affected by dam construction because of their lower reliance on upstream spawning habitat. They are found in all major tributaries above the confluence of the Klamath and Trinity rivers and in the river main stems (Moyle et al. 2008). Fall run Chinook return to both Iron Gate and Trinity River Hatcheries.

Upper Klamath fall Chinook salmon once ascended to spawn in habit, now-blocked, in middle Klamath tributaries (Jenny Creek, Shovel Creek, and Fall Creek), and in rivers in the Upper Klamath Basin, especially in wetter years (Hamilton et al. 2005). On the lower Klamath River, tributaries provide suitable spawning habitat. These include Bogus, Beaver, Grider, Thompson, Indian, Elk, Clear, Dillon, Wooley, Camp, Red Cap, and Bluff Creeks (Moyle et al. 2008). The Salmon, Shasta and Scott Rivers were historically and remain among the most important spawning areas for fall run Chinook, when sufficient flows are present. Spawning consistently occurs in the main stem Klamath River between Iron Gate Dam and Indian Creek, with the two areas of greatest spawning density typically occurring between Bogus Creek and the Shasta River and between China Creek and Indian Creek (Magneson 2006).

On the Trinity River, Upper Klamath fall Chinook once ascended above the site of Lewiston Dam to spawn as far upstream as Ramshorn Creek and historically, the majority of Trinity River fall Chinook spawning was located between the North Fork Trinity River and Ramshorn Creek. Currently, spawning is confined to the approximately 100 km between Lewiston Dam and Cedar Flat (Moyle et al. 2008). Important historic spawning tributaries above Lewiston Dam include the Stuart Fork, Browns and Rush Creeks (Moffett and Smith 1950). The distribution of redds in the Trinity River is highly variable (Moyle et al. 2008). The reaches closest to the Trinity Hatchery contain significant spawning but there is great variability in use of spawning habitat in reaches between the North Fork Trinity River and Cedar Flats (Quilhiullalt 1999)**.** Additional tributaries contain spawning fall run Chinook salmon in the Trinity River including the North Fork, New River, Canyon Creek, and Mill Creek (Moyle et al. 2008). In the South Fork, fall run Chinook once spawned in the lower 30 miles up to Hyanpom, and in the lower 2.7 miles of Hayfork Creek (LaFaunce 1967).

The distributions of both the fall and spring runs of Upper Klamath Chinook have contracted since the end of the 19th century. Because of the unique life history of the spring run, it has been most damaged by these changes, directly causing extirpation of several populations and making the run vulnerable to future genetic introgression with the other life history type in the Basin.



Compiled by M. Neuman, USBR Klamath Basin Area Office, 10/97

Figure 1. Klamath River Basin map with Klamath River dams

F. Population Status

Long-term population abundance data are limited for anadromous Klamath River salmonids. The earliest data primarily consist of catch records for Chinook salmon from early 20th century canneries (NMFS 2009). The data and information on Chinook salmon indicate that population levels have declined significantly since the early 20th century. NMFS 2009 review of all Klamath Basin salmonids reports that, “despite the lack of cohesive long-term data sets to assess population trends, the data that do exist indicate significant population declines in all species throughout the 1900s, leading to a current state of low abundance. Currently, a significant portion of Chinook salmon and coho salmon that return to spawn in the Klamath River Basin are fish that were spawned in hatcheries” (NMFS 2009).

Spring run

Spring Chinook salmon in the Upper Klamath Basin are at extremely low abundances compared to their historical status and their current low numbers make them vulnerable to extinction. This is stated clearly in the recent status review of salmon, steelhead, and trout in California:

> The numbers of spring Chinook in the Klamath and Trinity River have remained at low levels for the past 20 years with no obvious trends, but numbers are so low…that extirpation is a distinct possibility (Moyle et al. 2008).

Similarly, NMFS (2009) acknowledges the compromised status of spring runs in the Klamath Basin based on their unique life history and the resulting dangers to survival:

> Spring run Chinook salmon enter the Klamath River from April to June of each year before migrating to smaller headwater tributaries. They require cold, clear rivers and streams with deep pools to sustain them through the warm summer months. These areas have been greatly reduced in the Basin due to dams and degradation of habitat. The spring Chinook salmon run was historically abundant and may have been the dominant run prior to commercial harvest commencing in the mid-1800s. Wild spring run Chinook salmon populations are now a remnant of their historical abundance and primarily occur in the South Fork Trinity River and Salmon River Basins (NMFS 2009)

Upper Klamath spring Chinook were historically abundant in the Klamath River Basin and have since declined significantly due to a variety of threats. Moyle et al. (2008) state, "while it is likely that UKTR spring Chinook were historically the most abundant run in the Klamath and Trinity Rivers (Snyder 1931, LaFaunce 1967), by the time records were being kept seriously, they had been reduced to a minor component of Klamath salmon." In the past, populations of spring Chinook in the Basin likely totaled over 100,000 fish (Moyle 2002). The spring run was apparently the main run of Chinook salmon in the Klamath River until it declined steeply in the 19th century as a result of hydraulic mining, dams, diversions and fishing (Snyder 1931).

In each of four main Klamath tributaries (Sprague, Williamson, Shasta, and Scott Rivers), run sizes were estimated by CDFG (1990) to be at least 5,000. The runs in the Sprague, Wood, and Williamson Rivers were probably extirpated in 1895 after the construction of Copco 1 Dam (Moyle et al. 2008).

In 1968, efforts to maintain a spring Chinook run through artificial propagation of native stock at the Iron Gate Hatchery began (Klamath Task Force 1991). During the 1970s, approximately 500 fish returned each year to the hatchery but these attempts were eventually unsuccessful as the hatchery was unable to maintain the run without a source of cold summer water (Hiser 1985, Moyle et al. 2008).

The Shasta River run, probably the largest in the middle Klamath drainage, disappeared in the early 1930s as a result of habitat degradation and blockage of access to upstream spawning areas caused by Dwinnell Dam (Moyle et al. 2008). The Scott River spring run was extirpated in the early 1970s after a variety of human causes led to depleted flows and altered habitat (Moyle 2002). Along the middle Klamath River, spring run Chinook salmon are extirpated from their historic habitat except in the Salmon River (NRC 2004). Less than ten spring run Chinook return annually to Elk, Indian, and Clear Creeks (Campbell and Moyle 1991).

Moyle et al. state that "UKTR spring Chinook have been largely extirpated from their historic range because their life history makes them extremely vulnerable to the combined effects of dams, mining, habitat degradation, and fisheries, as well as multiplicity of smaller factors" (2008). By the 1980s, the spring run of Upper Klamath Chinook were largely eliminated from their habitat due to the loss or lack of access to the cold, clear water and deep pools they required for survival (NRC 2004). Spring run Chinook in particular must contend with low flows and high temperatures during up and down-river migrations that can prevent them from reaching their destinations or significantly increase mortality during migration (Moyle et al. 1995, Trihey and Associates 1996).

In the Trinity River, spring Chinook runs above Lewiston Dam included more than 5,000 adults in the Upper Trinity River and 1,000-5,000 fish each in the Stuart Fork Trinity River, East Fork Trinity River and Coffee Creek (CDFG 1990). These runs are now extinct. Over about the last thirty years, an average of 263 fish have been counted annually in the South Fork Trinity River, with runs as low as 59 (1988, 2005) and as high as 1,097 (1996). Between 1980 and 1989, an average of 142 spring Chinook were counted annually in the South Fork Trinity River; 351 fish between 1990 and 1999; and most recently 232 between 2000 and 2005. Historically, 7,000-11,000 spring run Chinook entered this stream (LaFaunce 1967) and outnumbered fall run Chinook in the watershed. Between 1980 and 2004, an average of 18,903 spring Chinook returned above Junction City on the main stem Trinity River. In 2004, 16,147 spring Chinook were estimated to migrate into this area with 6,019 (37%) of fish entering Trinity River Hatchery classified as spring Chinook (Moyle et al. 2008). Trinity River Hatchery releases over one million juvenile spring run Chinook every year and apparently all spawners in the main stem Trinity River are of hatchery origin (NRC 2004).

Hatcheries have severe negative effects on wild populations and are considered a high threat to both spring and fall Upper Klamath Chinook (NMFS 2009, J. Katz pers. comm. 2010). Interactions between wild and hatchery fish influence abundance, spatial distribution, life history diversity and productivity. For more details on the threat of hatcheries in the Basin, see "hatcheries" in the discussion of threats in this petition. The Trinity River population of spring Chinook is highly affected by hatchery fish and cannot be considered a viable wild population. Moyle et al. explain,

> Essentially, the only viable wild population today is in the Salmon River. Other populations are either small and intermittent or heavily influenced by hatchery fish, so may not be self-sustaining and are likely to be extirpated in the near future (Moyle et al. 2008). Spring run Chinook populations in the Salmon River, exhibit high variability among years. The 2005 adult count estimate was 90 fish, the lowest on record, but in 2007 the number reached 841 (Moyle et al. 2008) and in 2009, it was 643 (CDFG personal communication). In Wooley Creek, escapement

> has ranged between 0 and 81 during 1968-1989, but more recent surveys suggest spring run Chinook are nearly extinct in this watershed. In 2005, only 18 spring run Chinook were observed (Moyle et al. 2008).

The National Research Council (2004) also noted the low abundance and limited distribution of spring Chinook, especially those of wild spawning origin:

> In the Klamath River drainage above the Trinity, only the population in the Salmon River and Wooley Creek remains; it has annual runs of 150– 1,500 fish (Campbell and Moyle 1991, Barnhart 1994). Numbers of fish in the area continue to decline (Moyle 2002). Because the Trinity River run of several thousand fish per year is apparently sustained largely by the Trinity River Hatchery, the Salmon River population may be the last wild (naturally spawning) population in the basin.

Moyle et al. point out the current reliance of the spring run on this dwindling Salmon River population as they make conclusions about the status of the species:

> Overall, while spring Chinook salmon are still scattered throughout the lower Klamath and Trinity basins, the only viable wild population appears to be that in the Salmon River. Trinity River fish numbers are presumably largely influenced by fish from the Trinity River hatchery. Even if Trinity River tributary spawners are considered to be wild fish, the total number of spring Chinook in the combined rivers rarely exceeds 1000 fish and may drop to <300 in many years (2008).

In the 2008 status review, Moyle et al. report that the Upper Klamath Spring Chinook are “vulnerable to extinction in the next 50-100 years” based on the “fluctuating nature and small size of the Salmon River population and its localized distribution in a single watershed.”

This report produced the following table:

Table 2.

Metrics for determining the status of Upper Klamath/Trinity River spring Chinook salmon, where 1 is poor value and 5 is excellent.		
Metric	Score	Justification
Area occupied	2	Multiple populations exist including hatchery populations but only Salmon River is viable
Effective population. size	2	Although there is a hatchery stock, there are few natural spawners support the population.
Dependence on intervention	3	Hatchery program in Trinity is probably maintaining the Trinity run. The Salmon River wild population is vulnerable to extinction from both local and out-of-basin events. More human intervention necessary to preserve Klamath stock by re-establishing populations.
Tolerance	2	Temperature and other factors in summer holding areas may exceed physiological tolerances.
Genetic risk	2	Hybridization may be occurring in some watersheds with fall run fish; populations are low enough so genetic problems can develop.
Climate change	1	The Salmon River has temperatures in summer (21-23°C) that approach lethal temperatures. A 1-2°C increase in temperature could greatly reduce the amount of suitable habitat.
Average	2.0	12/6
Certainty	3	Monitoring efforts by USDA Forest Service, CDFG, tribes and local organizations give us reasonable information about status.

Spring Chinook are a CDFG Species of Special Concern and qualified to be added to the state and federal lists of threatened or endangered fish (Moyle et al. 2008). They are also considered a Sensitive Species by the Pacific Southwest Region of the US Forest Service.

Should NMFS choose not to consider the spring run of Upper Klamath Chinook as a separate ESU or DPS, the threatened status of the spring run within the current ESU is enough rationale for listing the entire current ESU under the Endangered Species Act. Protecting the spring run from extinction is essential to maintaining the diversity of the existing ESU regardless of whether the ESU is redefined or a spring run Chinook DPS is acknowledged. By NMFS precedent, an entire ESU may be listed under the ESA based on the threat to one of the life histories that composes it. According to Bilby et al. (2005), the loss of many of the spring run Chinook salmon populations from the Lower Columbia River ESU was one of the factors supporting the NMFS decision to list the ESU as threatened (NOAA 2003). The same is true of the Puget Sound Chinook ESU.

In describing foreseeable long term trends for Upper Klamath Spring Chinook, Moyle et al. conclude:

> UKTR spring Chinook have declined from being the most abundant run in the basin, to being a tiny run in danger of extinction. There are multiple possible futures for this distinctive salmon. The two extremes are extinction and restoration to a large segment of its historic range. At the present time it is headed for extinction. Climate changes will lead to increased water temperatures and fluctuations in many portions of the basin. Without drastic management measures,

> climate change will likely be the final blow to wild spring Chinook in the Klamath Basin. The run will then simply be a remnant hatchery run in the Trinity River for a few decades before it finally becomes so introgressed with the fall run so that it loses its genetic and life history distinctiveness. Alternately, there is potential for UKTR spring Chinook salmon to be restored to large portions of the Klamath basin through a few decades of restoration of habitat and habitat access (e.g., Shasta River, upper Klamath Basin) (2008).

Upper Klamath spring Chinook require immediate protections under the Endangered Species Act if they are to persist in the Klamath Basin.

Fall run

Compared to current numbers of Chinook salmon in the Upper Klamath and Trinity Rivers, runs were much larger historically (NRC 2004) and low abundance predictions of Klamath River Fall Chinook in recent years have forced severe harvest restrictions to West Coast fisheries (NMFS 2009). The vast majority of the fish today are fall run fish of both wild and hatchery origin" (NRC 2004) and most records of Chinook salmon abundance in the Basin were taken after the initial decline of spring run Chinook and therefore historical estimates tend to refer primarily to the fall run (Moyle et al. 2008). NMFS (2009) refers to sizable historic estimates in the Basin: "Based on records of commercial harvest, fall run Chinook are likely to have numbered 400,000 to 500,000 in the early 1900s. Runs in the last several decades have ranged from below 50,000 to 225,000 fish. These runs are substantially lower than historic levels." Snyder (1931) provided an early estimate of 141,000 fish, based on the 1912 fishery catch of 1,384,000 pounds of packed salmon. Moffett and Smith (1950) then estimated the Klamath River Chinook runs to be about 200,000 fish annually, from commercial fishery data from between 1915 and 1943. USFWS (1979) combined these statistics to approximate an annual catch and escapement of about 300,000 to 400,000 fish for the Klamath River system from 1915-1928 (Moyle et al. 2008).

The National Research Council (2004) reviewed historical estimates of fall Chinook:

> …the river harvest alone in 1916–1927 was 35,000–70,000 fish (as estimated from Snyder's data showing an average weight of 14 lb/fish and a harvest of 500,000– 1,000,000 lb each year). If, as Snyder's data suggest, the river harvest was roughly 25% of the ocean harvest in this period, annual total catches were probably 120,000–250,000 fish. This in turn suggests that the number of potential spawners in the river was considerably higher than the number spawning in the river today. Since 1978, annual escapement has varied from 30,000 to 230,000 adults. In both 2000 and 2001, runs were over 200,000 fish. If it is assumed that fish returning to the hatcheries are, on the average, 30% of the population and that 30% of the natural spawners are also hatchery fish, then roughly half the run consists of salmon of natural origin (including progeny of hatchery fish that spawned in the wild).

At the Klamathon Racks, a fish counting station close to the location of Iron Gate Dam, an estimated annual average of 12,086 Chinook were counted between 1925-1949, and the number declined to an average of 3,000 between 1956-1969 (USFWS 1979). In 1965, the Klamath River Basin was reported to contribute 66% (168,000) of Chinook salmon spawning in California's coastal basins (CDFG 1965). This production was distributed between the Klamath (88,000 fish) and Trinity (80,000 fish) basins, with approximately 30% of the Klamath Basin fish originating in the Shasta (20,000 fish), Scott (8,000 fish), and Salmon (10,000 fish) Rivers (Moyle et al. 2008). Snyder (1931) recorded the Shasta River as the best spawning tributary in the basin. It has since seen a marked decline in the number of fish returning. Leidy and Leidy (1984) estimated an annual average abundance of 43,752 Chinook from 1930-1937; 18,266 between 1938 and 1946; 10,000 between 1950 and 1969; and 9,328 from 1970-1976. A review of recent escapement into the Shasta River found an annual escapement of 6,032 fish from 1978-1995, and an escapement of 4,889 fish between 1995 and 2006 (CDFG 2006). In the Scott River, fall Chinook escapement averaged 5,349 fish between 1978 and 1996 and 6,380 fish between 1996 and 2006 (Moyle et al. 2008).

The National Research Council (2004) notes the drop in the population in the Shasta River as an important contributor to the overall decline of Upper Klamath Chinook:

> Additional evidence of decline is the exclusion of salmon from the river and its tributaries above Iron Gate Dam in Oregon, where fairly large numbers spawned, and the documented decline of the runs in the Shasta River. The Shasta River once was one of the most productive salmon streams in California because of its combination of continuous flows of cold water from springs, low gradients, and naturally productive waters. The run was probably already in decline by the 1930s, when as many as 80,000 spawners were observed. By 1948, the all-time low of 37 fish was reached. Since then, run sizes have been variable but have mostly been well below 10,000. Wales (1951) noted that the decline had multiple causes, most related to fisheries and land use in the basin, but laid much of the blame on Klamath River lampreys: the lampreys preyed extensively on the salmon in the main stem when low flows delayed their entry into the Shasta River.

In the Trinity River, Coots (1967) estimated an annual run of about 80,000 fish. Hallock et al. (1970) reported about 40,000 Chinook salmon entered the Trinity River above the South Fork. Burton et al. (1977 in USFWS 1979) estimated that 30,500 Chinook below Lewiston Dam on the Trinity River escaped between 1968 and 1972. The average fall Chinook run in the Trinity River between 1978 and 1995 was 34,512. This average declined between 1996 and 2006 to 23,463 fish (CDFG 2007).

The total in river escapement into this ESU ranged from 34,425 to 245,542 fish with an average 5-year geometric mean of 112,317 fish between 1978 and 2006 (Moyle et al. 2008). A large proportion of these fish are of hatchery origin and therefore do not contribute, and even constitute a threat to the long-term persistence of Chinook salmon in the Basin and (Bilby et al. 2005).

Hatcheries have played a major role in fall run Chinook salmon abundance since the 1960s (Moyle et al. 2008). Approximately 67% of hatchery releases have been fall run Chinook from

Iron Gate and Lewiston hatcheries (Myers et al 1998). Between seven and twelve million juveniles have been released annually (NRC 2004). Between 1997 and 2000, an average of 61% of the juveniles captured at the Big Bar outmigrant trap were hatchery origin fish (USFWS 2001) and at the Willow Creek trap on the Trinity River, between 1997 and 2000, 53% and 67% of the Chinook captured in the spring and fall were hatchery-origin fish, respectively (USFWS 2001). Some naturally-spawning fish are actually hatchery strays. Based on coded wire tag expansion multipliers, as much as 40% (Shasta River) of annual escapement consists of hatchery strays (R. Quinones, unpublished data as cited by J. Katz, pers. comm. 2010). As this region becomes dominated by hatchery fish, wild fish are threatened by greater competition, predation, disease transmission, and reduced fitness due to interbreeding with hatchery fish. As a region becomes dependent on hatchery fish, its ability to recover as a wild-spawning population of fish is highly compromised (ISAB 2005)

Upper Klamath-Trinity River fall Chinook are a US Forest Service Sensitive Species. They are managed by CDFG for sport, tribal, and ocean fisheries.

According to the Moyle et al. (2008) status review, fall run Chinook have declined from historical numbers of between 125,000 and 250,000 fish returning annually to the Basin to an average run size of about 120,000 since 1978 (from tables compiled by CDFG). Numbers in the past 25 years have sometimes reached this historical range but lower numbers are now typical and current runs depend heavily on hatchery production. Fall run Chinook have experienced a major downward trend in recent years, especially as a result of the 2002 kill in the lower river. Climate change will lead to even more threatening conditions for this ESU (Barr et al. 2010).

The Moyle et al. status review summarizes the long term trends for Klamath Basin Fall Chinook and reports:

> There is little reason to be optimistic about long-term trends in the future without major changes in watershed management. High summer water temperatures are a major driver of UKTR Chinook survival and they are likely to increase under most climate change scenarios. Likewise, changes in ocean conditions may cause decreased survival of fish once they leave the river (Moyle et al. 2008).

The report also points out that the increased reliance of the fall run on hatchery production is “likely masking a decline of wild production in the Klamath-Trinity basins”. Moyle et al. cited a 2005 report stating, “models evaluating limiting factors and habitat availability for UKTR Chinook salmon suggest that crucial steps need to be taken soon to increase UKTR fall Chinook spawners” (citing Bartholow and Henrikson 2005).

The National Research Council acknowledges that while fall Chinook have declined significantly, they may be good candidates for recovery under the right management reporting, “the fishery of the Klamath is particularly important…because of the possibility of maintaining it (NRC 2004). NRC goes on to note that both adults migrating upstream and juveniles moving downstream face water temperatures that are bioenergetically unsuitable or even lethal and that the vulnerability of the run to stressful conditions was dramatically demonstrated by the mortality of thousands of adult Chinook in the lower river in late September 2002.

Both spring and fall run Chinook have declined in the Klamath Basin with spring run Chinook demonstrating the most drastic trends of reduction. The spring run requires protections under the ESA in order to avoid extinction. Maintaining the spring run is essential to supporting the diversity of the current ESU and the vulnerability of this run in particular could justify listing the entire Upper Klamath-Trinity Rivers ESU according to the ESA.

IV. The Upper Klamath Chinook Salmon Qualifies as a Threatened or Endangered Species

A. Destruction, modification or curtailment of habitat or range

Dams

Dams in the Klamath Basin have destroyed Chinook habitat and forced modifications to the UKTR Chinook's range. Multiple reviewers rate dams as being a "high" threat to both spring and fall Upper Klamath Chinook salmon (NMFS 2009, J. Katz, pers. comm. 2010). The sequestration of habitat behind dams has acted as a major limiting factor to Klamath Basin Chinook populations, especially spring run Chinook and the presence of these dams has likely inhibited recovery in years when conditions would otherwise have permitted it. In addition, dams affect the quality of habitat downstream by preventing spawning gravel from traveling downstream (Moyle et al. 2008), releasing limited, warm, and sometimes toxic water, and dictating unnatural stream morphology or structure.

Dams have been a barrier for Upper Klamath Chinook since 1918, with the construction of Copco 1 Dam, closely followed by Copco 2 Dam in 1925. Iron Gate Dam represents the current extent of upstream migration for Chinook on the Klamath River. It was built in 1962 to produce hydroelectric power as well as to reregulate the wildly varying flows released by the Copco 1 and 2 Dams. In 1963, Lewiston Dam was built and became the current upstream limit to Chinook migration in the Trinity River.

Spring run Upper Klamath Chinook have been particularly affected by dams, as they spawned largely in areas that are now unavailable (Moyle et al. 2008). Above Iron Gate Dam, there are approximately 970 km of blocked Chinook habitat (Hamilton et al. 2005). The construction of Dwinnell Dam in 1926 on the Shasta River blocked habitat that led to the disappearance of the Shasta River spring run (NRC 2004). Half of the available spawning habitat in the Trinity River Basin was blocked by Lewiston Dam (Myers et al. 1998). These restrictions to Chinook spawning range have been widely implicated in the decline of Upper Klamath Chinook populations, particularly spring run populations, throughout the Klamath Basin. Another result of limits to upstream habitat has been the introgression of the spring and fall runs, leading to a decline in genetic variability and further threatening the long-term viability of the ESU (Moyle et al. 2008).

Dams also contribute to a reduction in spawning gravel. Gravel can be caught in reservoirs behind dams and is unable to travel downstream to spawning habitat. Limited access to spawning gravel has been reported to affect spawning prevalence in both the Shasta and Klamath Rivers (Kondolf 2000).

Dams have negative effects on downstream water quality. The water which is held behind dams is both stagnant and warm and serves to dramatically increase the prevalence of Harmful Algal Blooms (HABs) in reservoirs and downstream (Humborg et al. 2000, Anderson et al. 2002). Dams also decrease levels of dissolved silicon in the water, leading to changes and imbalances in downstream phytoplankton communities and increased human water use causes raised levels of nigrogen and phosphorous in reservoirs, all contributing to the prevalence and severity of HABs (Humborg et al. 2000, Anderson et al. 2002). HABs have been noted at abnormally high levels in both the Copco and the Iron Gate Reservoirs, such that the EPA demanded that California include microcystin toxin (released by HABs) as a cause of impairment in the Klamath River (EPA 2008). In 2006, microcystin toxins were measured in those reservoirs at 600 times the World Health Organization's recommended levels (EPA 2008). Higher levels of algal productivity also leads to increased decomposition, which in turn leads to lower levels of dissolved oxygen in the water (Correll 1998). In addition to causing HABs, reservoirs are also environments that harbor high levels of certain parasites affecting Upper Klamath Chinook (Bartholomew et al. 2007), and Chinook downstream from dams have been observed to have heightened infection rates from those parasites due to higher exposure doses (Bartholomew et al. 2007).

Channel morphology is altered by dams as well. Chinook salmon need a variety of different stream features to host a complicated interplay of biological and physical processes; they need the correct grades of gravel, the right depths and prevalence of deep pools, the existence of large woody debris, and the right incidence of riffles (Montgomery et al. 1997). Dams alter stream morphologies greatly, leading to a much narrower channel and a less complicated environment (Van Steeter & Pitlick 1998), which in turn leads to lower Chinook salmon populations (Montgomery et al. 1997). Meanwhile, reservoir morphology contributes to lower levels of dissolved oxygen (Cole & Hannan 1990). Low levels of dissolved oxygen have been noted on the Shasta River below the Dwinnell Dam, (CRWQCB 1993). The presence of dissolved oxygen is critical for the health of downstream fish populations. The particular effects of dissolved oxygen on Upper Klamath Chinook include serious problems with egg and embryo survival, as well as changes in behavior.

Dams have had a major impact on Upper Klamath Chinook populations. They have blocked off habitat throughout the Basin, prevented essential spawning gravel from traveling downstream, damaged water quality and changed channel morphologies of Klamath Basin streams. Dams both decrease available habitat greatly, and add to significant existing water quality problems in the Klamath.

Water withdrawals

Multiple reviewers consider water withdrawals to be either a high or intermediate risk to Upper Klamath Chinook (NMFS 2009, J. Katz, pers. comm. 2010). Since 1906 and the start of the Bureau of Reclamation's Klamath Project, a large portion of Klamath Basin surface and ground water has been withdrawn for agricultural uses. For decades this was done without considering the effects on anadromous fish in the Basin, and on Upper Klamath Chinook in particular (Foster 2002, Hecht & Kamman 1996). Agricultural water withdrawals have had a major impact on Upper Klamath Chinook populations, as resulting low flows and high temperatures cause stress and direct mortality of fish, contribute to disease prevalence and severity, and decrease Chinook egg survival.

The Project was constructed in order to reshape the dry hills of the Klamath Basin into agricultural land (Foster 2002), and wildlife have long played an inferior role in shaping land use policies in the Basin (Foster 2002). Historically, the Klamath Basin hosted a vast system of wetlands, shallow lakes, and marshes that effectively stored water during the wet season and released water in the main stem rivers during dry summer months, providing cool, clean water to fish and wildlife (Foster 2002). Today, over 80% of these wetlands have been drained in the interest of agriculture (Doremus & Tarlock 2003), eliminating key natural water storage resources in the basin. Without increased water storage and with intense competing uses, water withdrawals for agricultural use are, in their ongoing inefficient form, incompatible with the survival of Upper Klamath Chinook (Doremus & Tarlock 2003).

Water withdrawals in the Basin have increased steadily since they began and threaten fish survival in the Basin. In the Trinity River, from 1964-2004, 75-90% of the River's water was rerouted to the Central Valley for agricultural purposes (Moyle et al. 2008). Diversions into the A Canal (the primary diversion channel to the Klamath Project) increased from approximately 190,000 acre feet in 1929 to 290,000 acre feet in 1989 (Hecht & Kamman 1996), and 350,000 in 2010 (NMFS 2010). Under the pending Klamath Basin Restoration Agreement, farmers would be guaranteed levels close to the current average and significantly higher than historical rates, at 330,000 acre-feet (KBRA 2010), an amount incompatible with Chinook recovery and survival. The 2010 NMFS Biological Opinion on the Klamath Project stated that the lowered summer flows are undoubtedly connected to decreasing coho populations (NMFS 2010). Because Upper Klamath Chinook live in the same habitat as the species addressed in the Biological Opinion, the effects of withdrawals may be extended to Chinook salmon as well (NRC 2004). Since the listing of coho, stream flows in the Klamath Basin increased only briefly in 2001, before political pressure from irrigators forced the Bureau of Reclamation to resume irrigation in 2002 (Doremus & Tarlock 2003). The Ninth Circuit decision revising the NMFS ruling has supported resident coho, but has not resolved the Basin's overall crisis (NMFS 2009).

The Shasta and the Scott rivers are currently all but uninhabitable for Upper Klamath Chinook (Chandler 2009). In the summers of 2008 and 2009, both the Scott and Shasta rivers were at their lowest levels since flow recording began, with the Scott River's flow falling to two cfs on August 14th 2009, despite the fact that precipitation that year was at 77%. The Shasta River shared the Scott's predicament, with its flows almost reaching six cfs on October 11, 2008, when fall run Chinook normally spawn.

Water withdrawals have altered the natural hydrograph of the river and increased the seasonal variability by decreasing summer flows, which are most essential for the fall run of Upper Klamath Chinook (Hecht & Kamman 1996). The Upper Klamath Basin, with its porous volcanic rock and numerous wetlands and lakes, was historically a natural storage facility, contributing a large proportion of stream flows during drought years as well as late-summer months (Hecht &

Kamman 1996), with the snowpack contributing to flows mostly during the spring and summer (Hecht & Kamman 1996). One major effect of the combination of water withdrawals and dams is that the snowmelt peak that increased flows in spring and early summer is greatly reduced (Hecht & Kamman 1996). In 2010, the NMFS Biological Opinion stated that the altered hydrograph from the Klamath Project was harming coho (NMFS 2010). Chinook fry require water flow rates above certain levels (Allen 1986), and it is likely that this seasonal reduction in water flows arrives to the detriment of Upper Klamath Chinook populations.

High temperatures caused by water withdrawals and resulting low flows are a serious threat to Upper Klamath Chinook, causing increased stress levels and mortality. The temperatures in three Klamath Basin tributaries were measured every day in August and September of 2002. Average temperatures during September 2002, before the fish kill, ranged from 23°C to 17°C (Guillen 2003). Research shows that water temperatures in the Shasta exceeded 21°C on a daily basis for the entire summer season and through September during both 2002 and 2003 (Flint et al. 2005). Maximum temperatures in the Shasta reached nearly 30°C in mid July, far above temperatures which can lead to Chinook stress and mortality (Flint et al. 2005). Increased water temperatures due to low instream flows have affected spring run Chinook in particular (NRC 2004). Spring run Chinook generally need temperatures below 16˚C due to disease prevalence and loss of egg viability; but the deep pools holding spring run Chinook in the Salmon river have temperatures often exceeding 20˚C (NRC 2004).

Low flows and warm temperatures caused by water withdrawals also inhibit migration and cause crowding which create ideal conditions for disease outbreaks (McCullough 1999, NRC 2004). This was demonstrated during the Klamath Basin fish kill of 2002. Withdrawals above Iron Gate Dam in September of this year, immediately before the fish kill, reduced flows from the dam from an estimated 1441-1470 cfs (cubic feet per second) to 759 cfs (Guillen 2003) and these low flows were implicated as a cause for the rapid spread of Ich and Columnaris Diseas.

Other diseases thrive under warmer conditions as well. Many diseases that affect the Upper Klamath Chinook population are dormant at temperatures below 15.6°C (McCullough 1999). Increased levels of *Ceratomyxa shasta* infection in Klamath and Trinity Chinook populations Chinook were noted in 2009, with especially high rates immediately below the Iron Gate Dam where high temperatures are most apparent, upstream of major tributaries (True et al. 2010). This effect is no doubt also partly due to the fact that the stagnant, warm waters of reservoirs are ideal environments for *C. shasta* and their polychaete hosts (True et al. 2010).

Water withdrawals which lead to lower flows and warmer stream temperatures drastically decrease Chinook egg survival (McCullough 1999). The EPA has determined that temperatures above 13°C are unsuitable for Chinook spawning (EPA 2003). Temperatures above 15.6°C result in near total mortality for Chinook eggs (McCullough 1999). Higher water temperatures also result in smaller alevins and fry, as well as higher rates of alevin abnormality (McCullough 1999). The increased temperatures in the Klamath River in September and October have narrowed the available incubation period for Chinook eggs (Hecht & Kamman 1996) and may limit the species' overall reproductive success.

Water withdrawals are prevalent throughout the region and have caused dramatic changes to Upper Klamath Chinook habitat. This represents a persistent and ongoing threat to the long-term survival of this species in the Klamath Basin.

Logging

Historically, the Klamath Basin was heavily forested, with forest covering approximately 80% of the Upper Klamath Lake watershed alone (NRC 2004), providing stability and shade for streams. Logging in the Klamath Basin, after its beginning in the 1850s, expanded rapidly starting in the 1910s (NRC 2004); 120 million board feet of timber were logged in the upper Basin in 1920, and by 1941 timber harvesting increased to 808.6 million board feet in the upper Basin alone (NRC 2004). As of 2004, approximately 400 million board feet of timber were logged in the upper Basin annually (NRC 2004). Logging also involves the construction of road systems. In the Scott River watershed alone, more than 288 miles of logging roads were constructed as of 2004, as well as more than 191 miles of skid trails (NRC 2004). Logging is a particularly high threat for spring Chinook (J. Katz pers. comm. 2010). Logging poses a significant threat to Chinook habitat by increasing stream erosion, sedimentation and turbidity, blocking Chinook access to habitat, decreasing riparian shade, decreasing the presence of large woody debris, and leading to complications with wild fire.

Erosion and the resulting sedimentation of streams is likely the largest threat to Upper Klamath Chinook caused by deforestation. The Klamath Basin's geomorphology is particularly vulnerable to erosion, because of the steep and unstable slopes of the region (Moyle et al. 2008), and the particularly erosive soils that underlie much of the Basin, particularly in the Scott and Trinity River watersheds (NRC 2004). In the Upper Klamath Lake watershed, more than 73% of forest land is subject to severe erosion caused by logging (NRC 2004). Logging and associated road construction has long-lasting effects on the sedimentation and turbidity of nearby streams (Klein et al. 2008). Indeed, the sediment contribution to streams by roads is often greater than that from all other land-use activities combined (NMFS 1996). The construction of roads and trails in the lower Klamath Basin has been a "major source" of fine sediment in the Basin (NRC 2004). One study found that in the Scott River, average erosion for a road surface alone is 11 tons per acre; including the entire road prism, this figure rises to 149 tons per acre (Sommerstram et al. 1990). Skid trails, created during logging projects, are even more erosive, with trails in the Scott averaging an annual 239 tons of soil loss per acre (Sommerstram et al. 1990). It is estimated that 10%-55% of the eroded soil makes it into the Scott River as sediment (Sommerstram et al. 1990)

Furthermore, sediment is added to streams in logged areas long after the initial logging project has been completed (Klein et al. 2008). Indeed, the timber harvest rate seems to be the biggest factor contributing to high levels of turbidity measured in a stream, with an unlogged area made up of highly erosive geology, near the Klamath Basin, showing low turbidity levels (Klein et al. 2008), while logged streams nearby, with less erosive geology, showed higher turbidity levels (Klein et al. 2008).

Increased turbidity and sedimentation create adverse conditions for Chinook. The particular effects of fine sediment on Chinook and its habitat include lowered levels of dissolved oxygen, suffocation of eggs and alevins, and lowered ecosystem productivity, which results in lower levels of food available for juveniles (Cordone & Kelley 1961).

Logging has resulted in blocked and destroyed habitat for Chinook in the Basin. Spawning habitat has been restricted in the Klamath Basin during periods of low flows by aggradations due to erosion (USBR 2001) as well as through the creation of impassible barriers such as culverts (Hoffman & Dunham 2007). Shallow landslides caused by logging and road construction scour streambeds and decrease stream complexity, destroying Upper Klamath Chinook habitat (Dietrich & Real de Asua 1998). The incidence of shallow landslides is greatly increased by the presence of logging (Dietrich & Real de Asua 1998). Habitat is also undermined as sediment leads to fewer deep pools (Quigley & Arbelbide 1997).

Logging and associated roads have also been shown to lead to decreases in riparian vegetation (Quigley & Arbelbide 1997) which leads to increased stream temperatures (Bartholow 2000). Indeed, it is likely that the largest contribution to stream temperatures in most rivers is linked to decreased riparian vegetation (Bartholow 2000). The Shasta River, due to its structure–a relatively narrow channel–is particularly vulnerable to the lack of riparian shade (NRC 2004), and it is estimated that mature riparian vegetation would lower average maximum temperatures from 31.2°C to 24.2°C (NRC 2004).

Another effect of logging is reduced presence of large woody debris (LWD) in streams (Moyle et al. 2008). LWD is an essential element of Upper Klamath Chinook habitat (Rinella et al. 2009), as it helps form and maintain the deep pools necessary for juvenile Chinook, while aiding the recruitment of spawning gravel and creating cover for Chinook from predation (Rinella et al. 2009). LWD also contributes to stream productivity by adding habitat and food for the macrobenthic invertebrates that serve as food for juvenile Chinook (Rinella et al. 2009). Studies have shown that streams with LWD tend to harbor more salmonids, while LWD removal has been shown to lead to salmonid population decline (Rinella et al. 2009). In the Klamath Basin, logging on the Shasta River watershed has resulted in particularly low levels of LWD (NRC 2004). However, the 2010 coho Biological Opinion has found that lack of LWD is an issue in a “variety” of northern California and southern Oregon coho streams, many of which are also used by Upper Klamath Chinook (NMFS 2010)

As logging increases, so does the prevalence of wildfires (NRC 2004). The logging of old, large trees, especially when combined with fire suppression, results in more dense undergrowth, susceptible to fires (NRC 2004). Loggers often leave behind unsellable branches and detritus, which increase fire prevalence and severity (Donato et al. 2006). Since the early 1900s, the Salmon River, the last remaining viable habitat for Upper Klamath spring Chinook, has been battered by damaging crown fires, and now more than 50% of the Basin has burned (NRC 2004) with devastating effects. Short-term effects of wildfires on stream habitat include direct increases in stream temperatures, changes in stream pH, and the addition of toxic chemicals to the water (Engstrom 2010). Longer term effects include chronic and pulse erosion, channel reconfiguration, decreases in quality and quantity of large woody debris, reductions in streamside vegetation, and increases in both turbidity and stream sedimentation (Engstrom 2010).

After a fire has swept through the forest, permits are often granted for “post fire” or “salvage” logging, in an attempt to reduce future fires by taking out dead trees (Donato et al. 2006). However, there is evidence that post fire logging actually increases the risk of future fires (Donato et al. 2006), while also significantly reducing the regeneration rate of the forest (Donato et al. 2006). Studies on post fire logging after the Biscuit fire in the nearby Siskiyou National Forest (Donato et al. 2006, Thompson et al. 2007), found increased fire severity and decreased levels of regeneration in areas that have been “salvage” logged in comparison to areas left intact. Both scenarios have adverse effects on sediment levels in rivers as well as water temperatures, driving both effects upwards and consequently increasing the harm done to Upper Klamath Chinook populations.

Indirectly, logging roads also lead to habitat damage by providing access for forms of recreation that are harmful for Chinook (Quigley & Arbelbide 1997).

A significant portion of land in the Klamath River Basin remains open to logging. Land ownership in the Basin is 35 percent private, which is largely open to logging and urban and agriculture development with few protections in place for Chinook salmon or their habitat. In addition, there are over 700,000 acres, or roughly 16% of the basin, of Bureau of Land Management and the U.S. Forest Service lands that are designated as matrix lands under the Northwest Forest Plan, which are largely open to logging. See Table 3 for additional land ownership information:

Table 3.

Land Ownership in the Klamath River Basin Downstream from Dams

Agency	Land Use Allocation	Acres	% Watershed
U.S. Forest Service		2,772,123	62.66
	Adaptive Management Area	335,264	
	Adaptive Management Reserve	23	
	Administratively Withdrawn	80,482	
	Congressionally Reserved	732,577	
	Late Successional Reserve	825,339	
	Late Successional Reserve (Murrelet)	694	
	Late Successional Reserve (Owl)	15,849	
	Matrix	640,646	
	Riparian Reserve	132,274	
Private		1,533,024	34.65
U.S. Bureau of Land Management		98,179	2.22
	Adaptive Management Area	1,807	
	Administratively Withdrawn	6,104	
	Congressionally Reserved	4,462	
	Late Successional Reserve	4,166	
	Late Successional Reserve (Owl)	341	
	Matrix	66,191	
	Riparian Reserve	13,666	
Other*		20,860	0.47
Total Watershed Area		4,424,186	

*Other land owners include California Department of Fish and Game, California Department of Forestry and Fire Protection, California Department of Parks and Recreation, California State Lands Commission, City of Etna, Happy Camp Community Services District, Lake Shastina Community Services District, Other State Land, The Nature Conservancy, County of Trinity, U.S. Bureau of Reclamation, U.S. National Park Service, City of Weed, City of Yreka, and Weaverville-Douglas City Recreation District.

Logging remains a serious issue for Upper Klamath Chinook. Despite the legacy of sediment-choked streams, dangerously warm waters, and fire-vulnerable forests left by 100 years of heavy logging, forest management has continued in a destructive and unsustainable direction (NRC 2004). In combination with elements like water withdrawals and mining, what once might have been a mere irritant to Upper Klamath Chinook populations is further aggravating existing and serious threats to survival.

Mining

Historic mining in the Klamath Basin has caused damage to Upper Klamath Chinook habitat through the rearrangement of the landscape, increased sediment and mercury pollution. More recently, suction dredge mining has continued to affect Chinook in the Basin through the entrainment of fish and their food, increased erosion and the associated complications with sediment and turbidity. Also, suction dredge mining causes the destabilization of spawning and downstream habitat.

Beginning in the 1850s, miners arrived in the Basin in great numbers and major human-caused changes to Klamath Basin geography and ecology became widespread (NRC 2004). During the mid nineteenth century, gold rush miners used environmentally harmful methods of extracting gold from streams without regard for consequences (NRC 2004). One method, implemented in 1853, involved using high pressure water to blast away dirt and uncover placer deposits (NRC 2004). Many creeks were diverted into reservoirs for this purpose, and the jets of water unleashed sometimes washed away entire hillsides (NRC 2004). Much of the landscape in the Klamath Basin has been rearranged by this form of mining (NRC 2004). In California, before a court order mitigated some of the most harmful practices in 1884, hydraulic miners washed an estimated 1.6×10^9 yd^3 of sediment into the streams, hard rock miners created 3×10^7 yd^3 of mine tailings, and dredge miners left behind 4×10^9 yd^3 of debris, largely in the Klamath Basin (NRC 2004).

Historically, gold mining involved the use of mercury, large quantities of which was released back into the Klamath River (NRC 2004). It is estimated that with hydraulic mining, approximately one pound of mercury was released for every three to four ounces of gold recovered (NRC 2004) Much of that mercury remains in Klamath Basin soils and sediments, affecting Upper Klamath Chinook through leaching, as well as any animal or human that consumes them (NRC 2004). Even in the 19th century, the California government acknowledged the effects of mining on Klamath Basin salmon, and in 1852, it enacted its first salmon statute, though this piece of legislation had little practical effect (NRC 2004).

Much of the mining activity in the 19th century still affects whole streams in the Klamath Basin, and some areas, such as the Scott River, have been permanently damaged (Moyle et al. 2008). Even the Salmon River, now the last bastion for spring run Chinook, has approximately 16 million cubic yards of sediment, unleashed by mining between 1870 and 1950, slowly making its way downstream. This sediment harms juvenile habitat, fills in the deep pools needed for adult Chinook, and degrades spawning habitat by eliminating the correct grade of gravel (Moyle et al.

2008). Old gold mining practices have also left their mark on the Trinity River, an area of particular concern for mercury contamination (Alpers et al. 2005).

More recently, suction dredge mining has been used for extracting gold from the Basin. Dredge mining has been operating in California continuously since the invention of the suction dredge in the 1960s (CDFG 2009), and Upper Klamath Chinook populations have been directly impacted by this activity. Effects of suction dredge mining include the entrainment of juvenile fish and eggs (Harvey & Lisle 1998), as well as the entrainment of macrobenthic invertebrates that serve as food for juvenile Chinook (Moyle et al. 2008). Apart from entrainment of macrobenthic invertebrates that serve as an important food source for juveniles, the exposure of new substrate and the deposition of sediment in the streams causes localized reductions in both macrobenthic invertebrate presence and diversity (Harvey & Lisle 1998).

Dredging has long-term erosive consequences, increasing the sediment load of streams and altering habitat by filling deep pools and eroding stream banks that formerly served as shelter for the Chinook. Effects can last for years after the dredgers have left (Harvey & Lisle 1998). Similarly, dredging of riffle crests can cause them to erode, potentially destabilizing spawning habitats, filling deep holes, and destabilizing downstream reaches (Harvey & Lisle 1998). Furthermore, dredge mining that has disturbed riffle crest tends to channel the streamwater towards a stream bank, increasing streambank erosion (Harvey & Lisle 1998).

Suction dredge mining also stirs up sediment, adding to a stream’s turbidity (Harvey & Lisle 1998). Increased turbidity resulting from dredge mining can have negative effects on Upper Klamath Chinook, particularly juveniles. Increased levels of suspended solids in the water seem to result in increased foraging time by juvenile Chinook, as it reduces their reactive distance and prey capture success rate (Harvey & Lisle 1998). Higher levels of suspended sediment can also reduce primary production in a stream, as the sediment blocks off light needed for photosynthesis (Henley et al. 2000). This limits food available for organisms at higher trophic levels (Henley et al. 2000), including juvenile Chinook.

Suction dredge mining can also increase deposition of fine sediment downstream (Harvey & Lisle 1998), reducing both the benthic invertebrate populations that serve as food for Chinook (Harvey & Lisle 1998), and the availability of habitat for alevins inhabiting the benthic zone (Harvey & Lisle 1998). Increased fine sediment deposition also reduces dissolved oxygen levels by filling interstices between gravel and reducing water circulation in the hyporheic zone (Henley et al. 2000). The hyporheic zone is the zone of gravel and sediment that composes the streambed, where groundwater and surface water interact (Findlay 1995), and where Upper Klamath Chinook deposit their eggs. Increased fine sediment deposition due to mining is of particular concern in the Trinity and Salmon rivers (NRC 2004).

Suction dredge mining leads to the destruction of Chinook redds (Harvey & Lisle 1999). Miners dredge up and then deposit gravel that is seemingly the perfect size and density for Chinook redds, attracting spawning Chinook. The tailings placed back into the stream are unsupported however, and during the high flow period in winter after the Chinook have used the sediment for spawning, the gravel is swept downstream, killing any eggs present (Harvey & Lisle 1999). The same instability kills Chinook alevins inhabiting the gravel substrate (Harvey & Lisle 1998).

Mine tailings from suction dredge mining also reduce deep pools (Harvey & Lisle 1999) that are essential habitat for both juvenile and adult Chinook. The presence of unstable mine tailings used by Chinook as spawning grounds has been noted throughout the Klamath, Salmon, and Scott rivers and their tributaries (Moyle et al. 2008).

Other general effects include the loss of channel complexity, the loss of pool habitat, and the loss of effective large woody debris (NMFS 1998). Finally, the constant noise and turbidity caused by suction dredge mining raises the stress of Upper Klamath Chinook, increasing the possibility of premature death (Moyle et al. 2008).

Suction dredge mining currently poses a threat to Upper Klamath Chinook. Last year, California recognized the threat posed to salmonids by suction dredge mining and temporarily banned it in California streams, pending environmental review. The long-term damage has already occurred to Upper Klamath Chinook habitat, and with the very limited budget California can put towards enforcing the ban, many suction dredge miners are able to continue their activities with impunity. Mining has historically caused major damage to Chinook habitat in the Klamath Basin and remains a threat to their continued existence.

Chemicals

Land use in the Klamath Basin has resulted in the contamination of the region’s waters by a variety of chemicals including pesticides, herbicides, and insecticides. Basin agricultural lands discharge chemical and fertilizer-contaminated wastewater, and municipal wastewater also enters the system through the Lost River. Combined, these wastewater discharges result in harmful algal blooms, higher aquatic pH levels, lower levels of dissolved oxygen, and high concentrations of ammonia (NCWQCB 2010), all of which are destructive for Chinook populations (Moyle et al. 2008).

Pesticides, insecticides, and herbicides have been used in the Klamath Basin for at least 60 years (Dileanis et al. 1996).This includes the heavy use of dangerous organochlorine pesticides such as DDT in the 1950s and 1960s, which are found in Tule Lake and elsewhere in the Basin (Dileanis et al. 1996). In the early 1990s, 16 pesticides were reported in the waters of Tule Lake Refuge, with higher concentrations measured near agricultural drains (Dileanis et al. 1996). Between 1997 and 2001, approximately 27,000 pounds of the active ingredients of four forestry herbicides were used in the Klamath Basin. In 2002, research determined that some of the forestry herbicides were drifting into waterways (Wofford et al. 2003). So far in 2010, pesticide use proposals for 81 pesticides (including those known to be dangerous to wildlife) have been granted for lease lands within the Tule Lake and Lower Klamath National Wildlife Refuges (USBR 2010).

In long term studies, USGS (2009) found high levels of a variety of pollutants especially in the 20 miles between Link River and Keno Dam. Given the high levels of toxicity, the State of Oregon classifies this 20 mile reach as “water quality limited,” as required by Section 303(d) under the Clean Water Act (USGS 2009). Water quality in this region affects the quality of the entire main stem of the Klamath River. (Sullivan et al. 2010).

In 2008 the EPA issued a Biological Opinion on "the effects of the U.S. Environmental Protection Agency's (EPA) proposed registration of pesticide products containing the active ingredients chlorpyrifos, diazinon, and malathion on endangered species, threatened species, and critical habitat that has been designated for those species" (NMFS 2008). The Opinion assesses the effects of these pesticides on 28 listed Pacific salmonids and determines that the continued use of these chemicals is likely to jeopardize the continued existence of 27 listed Pacific salmonids and to destroy or adversely modify critical habitat for 25 of 26 listed Pacific salmonids, with critical habitat, including the Klamath Basin's Southern Oregon/Northern California Coast Coho (NMFS 2008). The population-level consequences of pesticide use discussed in this report included impaired swimming and olfactory-mediated behaviors, starvation during a critical life stage transition, death of returning adults, additive toxicity, and synergistic toxicity. Upper Klamath Chinook also negatively affected by these pesticides.

Diazinon, an organophosphate insecticide commonly used for general pest control, has been found to affect the olfactory nervous system of Chinook (Scholz et al. 2000). As Chinook depend largely on their olfactory system for homing, reproductive behavior, and pheromone activated anti-predator behavior, disruption of the sense of smell has wide-ranging negative effects on Chinook populations (Scholz et al. 2000). This disruption likely increases occurrence of Chinook "straying" (spawning fish returning to nontraditional spawning grounds), with results ranging from hybridization between hatchery and wild fish (Scholz et al. 2000) to lower densities of spawning Chinook in streams, leading to reproductive failure. Diazinon also negatively affects anti-predator behavior and the reproductive behavior of male Chinook (Scholz et al. 2000).

Other chemicals such as carbaryl, the third most commonly used insecticide in the United States, have been shown to neurologically affect salmonids (Labenia et al. 2007). Furthermore, pesticides seem to act synergistically, such that sub-lethal doses of two different pesticides may have effects greater than when they are encountered individually (Laetz et al. 2009). In one study, every pesticide tested acted synergistically with every other pesticide, and malathion and chlorpyrifos proved to be a particularly harmful combination (Laetz et al. 2009); both of those pesticides have been approved for use on Klamath Basin National Wildlife Refuge lease lands (USBR 2010), and are likely used to a much greater extent throughout the Klamath Irrigation Project.

Fertilizer and organic nutrients from agriculture and municipal wastewater present a serious threat (USGS 2009) by fueling algal blooms, depleting dissolved oxygen levels, and elevating pH levels (Smith et al. 1999). Algal blooms and subsequent fish die-offs are also linked to the presence of ammonia in the water (Rykbost & Charlton 2001). In the United States, eutrophication caused by agricultural runoff is the nation's largest water pollution problem (Smith et al. 1999) and the Klamath Basin is no exception. The Klamath Straits Drain, a concrete canal which collects the upper Basin's agricultural, refuge, and municipal wastewater and discharges it into the main stem of the Klamath River, has been designated "water quality limited" on Oregon's 303(d) list for dissolved oxygen and ammonia levels year round and for the water's pH and chlorophyll concentrations during the summer (USGS 2009). Discharge from the Klamath Straits Drain is impacted by high concentrations of total phosphates, biochemical oxygen demand, total solids, and ammonia and nitrate nitrogen throughout the year (ODEQ 1995).

Lowered dissolved oxygen (DO) levels due to impaired water quality as a result of agricultural and/or municipal inputs inflict harm on Upper Klamath Chinook (NCWQCB 2010). During July of 2008, the levels of DO measured above the Keno Dam were far below levels recommended for salmonids; if DO levels average lower than 3-3.3 mg/L, 50% mortality of juvenile salmonids is likely, while in water above 20˚C, daily minimum DO levels of 2.6mg/L are required to avoid 50% mortality (NCWQCB 2010). However, in 2008 from mid-July to mid-September at the Keno Dam, DO levels repeatedly dropped below one mg/L (sometimes to as low as .38 mg/L), and rarely rose to three mg/L (USGS 2009, Appendix B).

Nutrient loading of stream systems can lead to higher pH in river systems (NCWQCB 2010). The effects of a high pH on Upper Klamath Chinook are exacerbated by high temperatures (NCWQCB 2010), which is already a major water quality problem in the Klamath Basin. Due to impaired water quality as a result of agricultural, municipal, and other inputs as discussed, the Klamath River's pH in the summer often rises above 8.5, and sometimes reaches 9. At the Miller Island Boat Camp in 2008, the river's pH in early July, measured daily, had several consecutive days with pH values ranging from 9.06-9.53 (USGS 2009, Appendix B). Few direct studies examine the effects of high pH values on Chinook but rainbow trout are stressed by pH values above 9 and generally die if the pH value rises above 9.4 (NCWQCB 2010).

Nutrient loading in the Klamath River can increase ammonia levels as higher concentrations of nitrogen enter the water (NCWQCB 2010). High nitrogen concentrations, a product of water runoff from fertilized agricultural fields, also increases the toxicity of the ammonia present, as higher pH levels result in most of the ammonia morphing into its deadlier, un-ionized form (NCWQCB 2010). Ammonia in the Klamath River has been noted at levels high enough to harm Chinook through a reduction in hatching success; reductions in growth rate and morphological development; and pathologic changes in tissues of gills, livers, and kidneys (NCWQCB 2010). Ammonia also reduces Chinook disease resistance, and has been termed an exacerbating factor in Klamath River fish kills (NCWQCB 2010). The presence of high levels of un-ionized ammonia was noted in the Upper Klamath Lake in both 2007 and 2008 (USGS 2010).

In the Upper Klamath Lake, the combination of high pH (sometimes between 9 and 9.5 in late August) and temperatures (around 20˚C at the same time; USGS 2010) with high levels of ammonia can be dangerous. On August 25th, 2008, ammonia was measured at 0.933 mgN/L (USGS 2010), far above "acute" levels of ammonia for salmonids (0.885 mgN/L when the pH is 9; NCWQCB 2010). The USGS found that ammonia concentrations in the Klamath River actually increased in the downstream direction, with significantly higher levels found at the Keno Dam when compared to the Link River Dam (USGS 2009).

Agricultural and municipal wastewater delivered into the Klamath River is a severe threat to Chinook. Pesticides, even at sub-lethal doses, can combine to alter Chinook behavior, with major consequences for Chinook survival and reproduction. The eutrophication of traditional Upper Klamath Chinook habitat in the Klamath Basin results not only in levels of dissolved oxygen low enough to cause serious harm to Chinook populations, but also causes elevated pH levels, high concentrations of ammonia, and the presence of toxins produced by algal blooms.

Grazing

Grazing threatens Chinook in the Basin because of the loss of riparian vegetation, loss of large woody debris, increased sediment in streams, the addition of excessive nutrients to streams, and lowered water tables.

Grazing in the Klamath Basin has occurred since the late 1800s. As early as 1880, overgrazed fields caused a disastrous winter for plant life resulting in the mass mortality of cattle across the Basin (NRC 2004). More widespread effects were quickly noted, as a geologist in the early 1900s found formerly flat streams cutting channels in the land, as run-off increased due to overgrazing (NRC 2004). In an effort to save the nascent Klamath cattle industry, government agents recommended that wetlands be drained and planted with hay to provide feed for cattle, and in the 1890s, ranchers obliged, draining wetlands along the borders of the Upper Klamath Lake to provide increased forage (NRC 2004). In addition to lost water storage capacity and lower water quality caused by wetland draining, the flood irrigation of pastures to create cattle feed as well as the switch to nonnative species of hay severed healthy riparian connections to the landscape (NRC 2004). Because cattle are attracted to riparian areas for grazing, damage caused by intense cattle presence is often concentrated in sensitive riparian areas (Belsky et al. 1999). The Scott and Trinity rivers have been degraded by under-regulated grazing and ranching, as have numerous small tributaries that contribute their flows to the Klamath River (NRC 2004). In the South Fork Trinity River, unsustainable grazing and farming practices, combined with large floods in 1964, have resulted in long-term loss of viability to salmon populations (NRC 2004). Populations in the South Fork Trinity River have made little progress recovering in the intervening decades (NRC 2004).

One major of effect of grazing in riparian habitats is the decrease riparian vegetation. Throughout the Klamath Basin, there is evidence that unfenced grazing results in the loss of vegetation through animal consumption and trampling (NRC 2004). Grazing is the primary contributor to the lack of riparian vegetation in the upper Shasta River (NRC 2004). Loss of riparian vegetation leads to increased stream temperatures as well as a decrease in the quality of Chinook habitat through the loss of large woody debris (NRC 2004) increased erosion and sedimentation, all of which have highly damaging consequences to Chinook salmon.

Cattle also cause increased levels of nutrients to be added to river systems. The effects of season-long grazing in the past in the Sprague River (a major tributary to the Upper Klamath Lake) have resulted in the Oregon Department of Environmental Quality labeling the Sprague River in the Upper Klamath Basin as one of the worst streams in Oregon for non point-source pollution (NRC 2004). Animal waste from grazing adds nutrients to water systems that can result in HABs (Belsky et al. 1999). The Sprague River is a contributor of extremely high levels of phosphorus due to poor land use practices (NRC 2004), including grazing. As phosphorus is the primary factor limiting algal blooms in freshwater systems (Anderson et al. 2002), its input is likely to be a major cause of HABs, which can have large effects on downstream Chinook populations, through the release of toxins (EPA 2008) and lowered levels of dissolved oxygen (Correll 1998).

Grazing has also been implicated in lowering water tables; as water flows downhill during floods, it is trapped by riparian plants, slowing flows and allowing the water to percolate through the sub-soil to become groundwater (Belsky et al. 1999). Extensive grazing, combined with groundwater withdrawals and sprinkler irrigation is a significant contributor to the problem of low water tables in the Scott River watershed (NRC 2004, Van Kirk & Naman 2008).The impact of low water tables in these critical Klamath River tributaries and throughout the upper Basin translates directly to limited river flows and impaired water quality for Upper Klamath Chinook downstream.

The legacy effects of grazing have permanently harmed Upper Klamath Chinook habitat and current ranching practices continue to impair the viability of populations through impacts on water quality. For every cattle herd grazing on upper Basin rangeland, water quality for downstream Upper Klamath Chinook populations is further degraded.

B. Overutilization

Commercial, recreational and tribal fishing have had a combined effect on Klamath River salmonids that have contributed to their decline since the 19th century (NMFS 2009; Snyder 1931). Both legal and illegal harvest combined pose a high threat for both spring and fall Upper Klamath Chinook (J. Katz pers. comm. 2010). Harvest of Upper Klamath Chinook salmon has added to the decline of both the spring and fall runs and continues to threaten the long-term persistence of Chinook in the Basin (Moyle et al. 2008).

Ocean harvest is currently managed through the Pacific Coast Salmon Fishery Management Plan (Salmon FMP) in accordance with the Magnuson Stevens Fishery Conservation and Management Act (MSA) of 1976. The Salmon FMP was developed by the Pacific Fisheries Management Council (PFMC) and each year, the PFMC develops management measures for ocean salmon fisheries based on the weakest stocks within the “mixed stock” found in the ocean (NMFS 2009). In the 1998 NMFS status review, Myers et al. referred to Upper Klamath Chinook populations as failing to meet modest spawning escapement goals despite active harvest management.

Excessive harvest, when combined with poor ocean conditions severely affects Upper Klamath Chinook salmon escapement. In an effort to increase natural spawning escapements, the PFMC accepted new fisheries guidelines in November 2006 (Moyle et al. 2008). These guidelines were considered a compromise to account for: 1) recent and critically low spawner abundances in consecutive years; 2) the risk that populations were dropping below critical genetic thresholds; 3) prevailing ocean conditions; and 4) Endangered Species Act considerations (PFMC 2007 as cited in Moyle et al. 2008).

In April 2008, the PFMC recommended and the Secretary of Commerce approved the most restrictive salmon fisheries in the history of the West Coast. These restrictions came as a direct response to the sudden collapse of the Sacramento River Fall Chinook Salmon. In September of 2008, the PFMC recommended that a plan be produced to rebuild Klamath River fall Chinook salmon due to an “overfishing concern” which was triggered in 2007 (NMFS 2009).

Moyle et al. (2008) conclude that the combined conditions of Central Valley and Klamath River salmon stocks will result in greatly restricted ocean and sport fisheries for an extended time period. One solution to be considered by managers is for all hatchery fish to be marked and for fisheries to be allowed take of only hatchery fish, therefore providing a safety mechanism for wild spawning Chinook in the Basin (Moyle et al. 2008). Marking of all hatchery fish would also allow measures to ensure hatchery fish are not mixing with wild fish on key spawning grounds.

Moyle et al. (2008) identifies legal and illegal harvest as a major limiting factor affecting both spring and fall runs of Upper Klamath Chinook. Both illegal harvest of holding adults and legal, ocean and river harvests contribute to reduced spawning populations. Adults holding upstream in deep pools are especially vulnerable to illegal take; although these numbers are largely undocumented, it can be assumed that spring run Chinook holding in pools in the Klamath River and elsewhere in the Basin are affected by harvest from pools where they are holding prior to spawning. There is a general absence of spring Chinook from populated areas in the Klamath, and in areas with easy access to humans, further suggesting that illegal harvest is occurring. The illegal removal of even a small number of spring run Chinook likely has an intense effect on spawning populations (Moyle et al. 2008).

Because managing agencies do not treat spring run Chinook differently from fall run Chinook, spring run fish are taken legally in commercial and sport fisheries (Moyle et al. 2008). Harvest rates are defined based on combined spring and fall run numbers of both hatchery and natural origins. Therefore the dwindling populations of spring run Chinook, especially wild-spawning populations are particularly vulnerable to being overfished under current management (Bilby et al. 2005).

C. Disease or predation

Disease

Several diseases affect the Upper Klamath Trinity River Chinook salmon and will likely continue to pose a threat to this ESU in the future. Salmon are exposed to a variety of bacterial, viral and parasitic organisms throughout their life cycle, contracting diseases through both waterborne pathogens and through mingling with infected hatchery fish (NMFS 1998). It is possible for a fish to be infected with one or more pathogen but not to show signs of disease. Hatchery Chinook salmon appear to be more susceptible to disease than naturally spawning Chinook (NMFS 1998). Because Chinook salmon in the Klamath River Basin emigrate as juveniles and return to spawn when water temperatures and flows approach their limits of tolerance, they are particularly susceptible to disease (Moyle et al. 2008, NMFS 2009).

In 2002, a major fish kill occurred in the second half of September in the lowermost 40 miles of the Klamath River main stem. At least 33,000 Chinook died out of a total estimated run of 130,000 fish (NRC 2004). Although the original FWS report of estimated mortality claimed about 33,000 fall Chinook died in this fish kill, a more updated report by CDFG explains that the estimate was “conservative and DFG analyses indicate actual losses may have been more than double that number” (CDFG 2004). This was the largest known pre-spawning die-off recorded for the region and possibly the whole Pacific coast (Guillen 2003). Stressful environmental conditions combined in 2002 for Columnaris and Ich to sweep through a population of already stressed fish (Guillen 2003). Factors which combined included high temperatures, crowded conditions and low flows. In response to high water temperatures and low flows, fish stopped migrating and instead concentrated in cooler deep pools, creating optimal conditions for the proliferation of pathogens. All of the specimens examined during the die-off were infected by Ich and/or Columnaris Disease (Guillen 2003).

Columnaris is bacterial pathogen affecting Upper Klamath Chinook salmon and is caused by *Flavobacterium columnare*. The disease is associated with pre-spawn mortality of spring run Chinook especially when they are exposed to above-optimal water temperatures (Moyle et al. 2008). Columnaris is usually pathogenic at temperatures above 15º C and outbreaks are common in adult populations held at hatcheries in water at 15-18º C (Guillen 2003). The earliest sign of Columnaris is a thickening of the mucus at various spots on the fish (Guillen 2003). When it becomes more developed, fish will show small bloody spots on the skin. Eventually, respiratory and osmoregulatory function is lost at the gill surface and the fish dies (Post 1987). Although typically widespread, Columnaris only causes widespread mortality when associated with high degrees of stress. This occurred during the 2002 fish kill in which Columnaris was one of the two diseases implicated as a direct cause of mortality. By 2004, only 2.4% of fish examined were infected with *F. columnare* suggesting that it was not a significant problem in these fish in 2004 (Nichols and Foott 2005).

The other pathogen which directly caused the major fish kill in 2002 is Ich disease, caused by the ciliated protozoan, *Ichthyopthirius multifilis*. The optimal temperature for Ich development is 21.1-23.9º C and within this range, higher temperatures cause faster replication of the parasite (Guillen 2003). Ich disease reduces the capacity for fish to absorb oxygen and excrete ammonia and mortality occurs when gills become too damaged to function (Post 1987). Studies show that higher water velocities reduce and may prevent Ich disease outbreaks completely because of a decreased probability of the parasite finding a host before being swept downstream (Guillen 2003).

The USFWS and CDFG monitored the health and physiology of salmonids in the Klamath and Trinity River Basins from 1991-1994 and identified *Ceratomyxa shasta* as the most significant disease affecting juvenile salmon in the Klamath Basin (Nichols and Foott 2005). *C. Shasta* is a myxozoan parasite that appears in the mainstem and Upper Klamath River, Copco Reservoir, both Klamath and Agency Lakes and the lower reaches of the Williamson and Sprague Rivers (Moyle et al. 2008). It is often found in reservoir environments so that dams on the Klamath River have contributed to the spread of this parasite. Soon after Iron Gate Hatchery was established, operational problems associated with *C. shasta* began to occur and significant outbreaks continued to occur into the early 1980s (NMFS 1998). A 1989 study found that Chinook salmon at Iron Gate Hatchery had a 4% susceptibility to *C. shasta* and a 19% susceptibility at the Trinity River Hatchery (Carlton 1989 as cited in NMFS 1998). *C. shasta* infection appears to be accelerated when high densities of infected fish are combined with warm water temperatures (Foott et al. 2003).

Nichols and Foott monitored the health of juvenile Klamath River Chinook Salmon. They estimated that 45% of the population was infected with *C. shasta* (Nichols and Foott 2005). Of the fish infected with *C. shasta*, 98% were also infected with another myxozoan infection, *Parvicapsula minibicornis*. The dual infection suggested that the majority of fish infected with *C. shasta* as juveniles would not survive.

More recent studies have revealed some of the factors affecting incidence of *C. shasta* infections and identified this parasite as a potentially limiting factor to the survival of Klamath River Chinook. Petros et al. (2007) studied the effect of water flows on the incidence of *C. shasta* to find out whether drought exacerbated fish health issues by concentrating spores in reduced flows and compromising resistance through increased stress from warm water temperatures. The years 2005 and 2006 had higher flows than 2004 and exposure to *C. shasta* was less severe in the years with higher flows. However, the 2006 results were not as pronounced as expected given the magnitude of the spring 2006 water levels (Petros et al. 2007).

Bjork and Bartholomew (2009) investigated the effects of water velocity on presence of *C. shasta* in *Manayunkia speciosa*, the pathogen's intermediate polychaete host. In faster water velocities, the polychaete density was higher but the prevalence of *C. shasta* was lower and the severity of infection in fish was also decreased. Another study by Bjork (2010) showed that temperature had no effect on polychaete survival but that higher temperatures caused actinospore release in *C. Shasta* to occur earlier and in greater abundance. *C. shasta* infections can be expected to grow more severe in conditions of low flows and high temperatures.

Parvicapsula minibicornis the other myxozoan parasite common to the Klamath River and although often present, like *C. Shasta* it is not always abundant nor do the conditions always exist for large numbers of Chinook salmon to be infected (Moyle et al. 2008). *P. minibicornis* appears to be highly infectious. It was estimated to infect 94% of the population of juvenile Chinook in the Klamath River in 2004 (Nichols and Foott 2005).

Another prevalent pathogen in the Klamath River Basin is Bacterial Kidney Disease (BKD) caused by the Bacterium, *Renibacterium salmoninarum.* In 1994, BKD was cited along with the trematode parasite, *Nanophyetus salmicola*, as one of the most significant pathogens affecting both natural and hatchery smolt health in the Basin (NMFS 1998). The pathogen can prevent fish from making the necessary changes in kidney function during smoltification (NMFS 1998). Also, the stress of migration can cause BKD to come out of remission (Schreck 1987).

Climate change is expected to cause increased water temperatures and therefore higher stress conditions that can be expected to increase the occurrence and severity of disease outbreaks among Chinook salmon in the Klamath Basin. Warmer temperatures favor disease outbreaks (Moyle et al. 2008). Disease has been a direct cause of mass mortalities in the Klamath Basin in the past and will present further challenges for their continued survival due to changing conditions in the future.

Predation

Combined with other threats, predation plays a role in affecting population level dynamics among Pacific salmonids, including Upper Klamath Chinook. Predation is an increasing threat to this ESU.

Upper Klamath Chinook are preyed upon throughout their life history. Predation of eggs is usually not a major cause of mortality given that eggs are buried in the substrate, but some egg predation does occur by other fish species and invertebrates, including oligochaete worms, particularly if the eggs are not buried deep enough in gravel (Allen and Hassler 1986). During spawning, predation occurs from bears and otters, while during rearing and migration downstream, freshwater fish species, and avian predators have been shown to prey on juvenile salmonids (NMFS 1998). According to Healey (1991), fish and invertebrate predation are the two most important causes of mortality during Chinook freshwater residence. Chinook in the near shore and estuarine life stage are exposed to contact with avian predators including herons and diving birds such as cormorants and alcids (auklets, murres, murrelets, guillemots, and puffins; Allen 1974 as cited in NMFS 1998). NMFS (1998) predicts that as the quality of riverine and estuarine habitat decreases, avian predation will increase and affect salmonids to a greater extant. During ocean residence, predator relationships are almost impossible to fully investigate; however, before their migration upstream, Upper Klamath Chinook are exposed to concentrations of marine mammal predators in the estuary and at the mouth of the Klamath River, including sea lions.

Several earlier investigators have claimed that predation is not a limiting factor for Chinook salmon populations (Botkin et al. 1995, Hanson 1993). Anadromous salmonids have historically coexisted with both marine and freshwater predators as these species evolved together (NMFS 1998). In fact, predators play an important role in healthy prey populations by culling unfit individuals and thereby strengthening the population as a whole. In studies of marine mammals, salmonids have been found to be a minor component of the diet (Scheffer and Sperry 1931, Jameson and Kenyon 1977, Graybill 1981, Brown and Mate 1983, Roffe and Mate 1984, Hanson 1993, Kvitrud et al. 2005) and the main food sources for marine mammals include lampreys, benthic and epibenthic species and flatfish (NMFS 1998).

Though Chinook salmon and their predators have co-evolved, human-induced changes have affected the dynamics between Chinook salmon and their predators to create more adverse conditions for Chinook salmon. Increased predator populations in Chinook habitat have shifted the predator-prey dynamic for Chinook salmon (NMFS 1998). In the Snake River at Lower Granite Dam, a study in 1990 showed that 19.2% of adult spring and summer Chinook salmon observed exhibited wounds that were attributable to marine mammals, primarily harbor seals (NMFS 1998). Prior to 1990, the percent of adult salmon injured as a result of marine mammal attacks was considered to be only a few percent annually (NMFS 1988). Even when fish survive wounds inflicted by predators, they are more prone to mortality through disease, and stress, especially when exposed to warm water conditions (NMFS 1998), as are found in the Klamath Basin. McCullough (1999) notes that temperatures above 17º C are associated with increased predation. The large number of hatchery fish released in the Klamath Basin has also been implicated as a source of predation for wild-spawned juvenile Chinook salmon (Moyle et al.

2008). The massive decline of Upper Klamath Chinook in the historically abundant Shasta River was attributed largely to predation by Klamath River lampreys that preyed extensively on the salmon in the main stem when low flows delayed entry into the Shasta River (NRC 2004).

The large-scale modification of habitat in the Klamath River Basin has resulted in conditions that favor predators. The human-induced loss of avoidance habitat for fish, including deep pools and estuaries, large woody debris, and undercut banks, has created conditions in which some Chinook stocks are likely further reduced by avian predation (NMFS 1998). In a report on factors affecting salmonid stocks in Northern California, the loss of large deep pools in lower main stem rivers was cited as reducing holding habitat. Fish awaiting improved conditions must hold in the estuary or off the mouth of rivers, increasing their vulnerability to predation by marine mammals and to ocean fisheries (Higgins et al. 1992).

Strange (2007) reported on interactions with marine predators while studying adult Chinook salmon migration in the Klamath River Basin through the tagging and monitoring of 88 adult Chinook. Of those fish tagged, 26 (30%) eventually migrated upriver out of the estuary while 62 (70%) never migrated beyond the estuary. This was significantly more than previous study years in which 43-56% never migrated beyond the estuary. Of those that did not initiate post-estuary migration, 2 (3%) were harvested, 6 (10%) likely regurgitated their tags, 25 (40%) disappeared with no further detections, and a total of 29 (47%) were eaten by pinnipeds, in particular, California sea lions. It is likely that the actual number predated upon was higher than the confirmed instances. Strange (2007) acknowledges that the high-incidence of predation is likely inflated due to the increased vulnerability of fish immediately after being tagged. However, the study occurred after a documented increase in predation by marine mammals in previous years; Williamson and Hillemeier (2001) found that in 1998 and 1999 the predation rates for the entire fall Chinook run ranged from 2.3-2.6%, with California sea lions responsible for 89.8-93.5% of this predation. When these results were compared to studies conducted 10-20 years earlier, it was concluded that temporal presence and associated predation pressure from California sea lions was increasing. Assuming this trend continued, the Strange (2007) study is likely an indicator of an ongoing increase in pinniped predation on Upper Klamath Chinook salmon.

Strange (2007) identified the presence of pinnipeds as an important factor in defining adult Chinook behavior in the estuary, specifically the timing of estuary residence. The estuary served as a physical bottleneck in which actively hunting pinnipeds congregated to feed on holding adult Chinook. The Klamath River estuary serves as the largest thermal refuge in the entire Klamath River Basin, with the exception of cold water reaches below Lewiston Dam and in the headwaters of mountainous tributaries. Strange (2007) reported an observed general lack of substantial residence times in the estuary and Chinook salmon were observed to stage in near shore ocean water. This indicates that predator avoidance was a primary driving factor in Chinook behavior, and predator pinnipeds created a "substantial deterrent to residing in the estuary more than the minimum necessary for adult Chinook" (Strange 2007). Migrational delays due to adverse temperature conditions result in a trade-off between the associated costs (e.g. increased predation or energy expenditures) and benefits (e.g. avoiding lethal conditions; Strange 2007). Therefore, when exposed to adverse temperature conditions due to low, warm freshwater flows, they also become more exposed to predation.

Chinook salmon in the Klamath River Basin are exposed to predation throughout their life cycle. It affects population dynamics and may become an increased threat as habitat conditions change for the worse.

D. Inadequacy of existing regulatory mechanisms

As abundantly documented in this petition, Upper Klamath Chinook face severe threats from multiple factors. Existing regulatory mechanisms are entirely inadequate to address these threats and ensure the survival of the species. By considering Upper Klamath spring and fall Chinook as part of the same ESU, NMFS has limited adequate protection of spring Chinook under the ESA so that they are directly at risk of extinction. Current federal and state regulations which may indirectly affect these fish lack the protection needed by Upper Klamath Chinook.

Federal Regulatory Mechanisms: U.S. Forest Service

In the United States, the National Environmental Policy Act (NEPA) requires Federal agencies, including agencies within the Department of Interior, Department of Agriculture (e.g. United States Forest Service), and beyond, to consider the effects of management actions on the environment. NEPA does not, however, prohibit Federal agencies from choosing alternatives that may negatively affect Upper Klamath Chinook salmon.

Upper Klamath Chinook are listed as a sensitive species by the Forest Service in Region 5, requiring analysis of impacts to the salmon from management actions or changes under NEPA. Because NEPA does not require avoidance of harm, this affords little protection. The Forest Service must analyze the impacts of their actions on the species, but as above are not required to select alternatives that avoid harm to Chinook. Indeed, the Forest Service regularly plans timber sales, maintains and utilizes roads, allows livestock grazing and conducts other actions that harm Upper Klamath Chinook.

Relevant National Forest Plans include Six Rivers National Forest, Shasta-Trinity National Forest and Klamath National Forest. The forests are responsible for maintaining suitable fish habitat that will support well-distributed, viable populations of native fish. Forest service sensitive species including the Upper Klamath Chinook are considered in planning decisions such as habitat improvement and restoration. Sensitive species are considered when establishing key watersheds within National Forest Plans. Standards and guidelines for key watersheds include analysis prior to management activities, prioritization of sensitive species during restoration activities and restrictions on the building of new roads. National Forest Plans do not have the authority to maintain fish habitat on private lands nor to regulate actions by private parties which are destructive to Upper Klamath Chinook (mining, agriculture and timber operations) and the plans are therefore insufficient to protect Chinook salmon in the Basin.

The NWFP, signed and implemented in April 1994, represents a coordinated ecosystem management strategy for Federal lands administered by the USFS and BLM within the range of the Northern spotted owl (which overlaps considerably with the freshwater range of Chinook salmon).

The most significant element of the NWFP for anadromous fish is its Aquatic Conservation Strategy (ACS). This regional scale conservation strategy includes: (1) Special land allocations, such as key watersheds, riparian reserves, and late-successional reserves, to provide aquatic habitat refugia; (2) special requirements for project planning and design in the form of standards and guidelines; and (3) new watershed analysis, watershed restoration, and monitoring processes. These components are designed to ensure that Federal land management actions achieve a set of nine Aquatic Conservation Strategy objectives, which include salmon habitat conservation. In recognition of over 300 ‘‘at-risk’’ Pacific salmonid stocks within the NWFP area (Nehlsen et al., 1991), the ACS was developed by aquatic scientists, with NMFS participation, to restore and maintain the ecological health of watersheds and aquatic ecosystems on public lands. The ACS attempts to maintain and restore ecosystem health at watershed and landscape scales to protect habitat for fish and other riparian-dependent species and resources and to restore currently degraded habitats. The approach seeks to prevent further degradation and to restore habitat on Federal lands over broad landscapes.

The overall effectiveness of the NWFP in conserving Upper Klamath Chinook salmon is limited by the extent of Federal lands and the fact that Federal land ownership is not uniformly distributed in the ESU. In some areas, particularly Bureau of Land Management (BLM) ownership, Federal lands are distributed in a checkerboard fashion, resulting in fragmented landscapes. This factor places constraints on the ability of the NWFP to achieve its aquatic habitat restoration objectives at watershed and river basin scales.

In addition, a significant portion of land in the Klamath River Basin remains open to logging under the NWFP. Land ownership in the Basin is 35 percent private, which is largely open to logging and urban and agriculture development with few protections in place for Chinook salmon or their habitat. In addition, there are over 700,000 acres, or roughly 16% of the basin, of Bureau of Land Management and the U.S. Forest Service lands that are designated as matrix lands under the Northwest Forest Plan, which are largely open to logging.

Under the National Forest Management Act, the Forest Service is required to “maintain viable populations of existing native and desired nonnative vertebrate species in the planning area” (36 C.F.R. §219.19). As with NEPA, this requirement does not prohibit the Forest Service from carrying out actions that harm species or their habitat, stating only that “where appropriate, measures to mitigate adverse affects shall be prescribed” (36 C.F.R. §219.19(a)(1)). This clause does little to limit long term impacts to salmonid habitat in the Klamath Basin. Also, these regulations are currently under review and any protection they afford may be removed at any time.

Despite all of these laws and plans, federal land managers have continued to plan and implement projects that harm Upper Klamath-Trinity River Chinook salmon. Destructive actions have included timber sales on steep slopes, logging of riparian reserves, failure to maintain, fix and remove roads as necessary, and problems with grazing, including inadequate and unenforced best management practices (BMPs). Also, the U.S. Forest service has failed to advocate for stream flows in the lower Scott River which is under their jurisdiction. Federal land managers in the Basin are not taking sufficient actions to manage for the persistence of Chinook salmon and better practices are necessary for conservation of these fish.

Federal Regulatory Mechanisms: FERC

The Federal Energy Regulatory Commission (FERC) is charged with relicensing the Klamath Hydroelectric Project (FERC P-2082-000) on the Klamath River every 20 years. The FERC license for operation of the Klamath Project expired in 2006 and FERC produced an Environmental Impact Statement (EIS) for the Project in 2007. In a new national era of dam removal, FERC has supported negotiations regarding antiquated hydroelectric projects like on the Klamath River in place of intensive and costly dam improvements. PacifiCorp has continued to operate the Project despite pending relicensing due to the ongoing negotiations over the Klamath Basin Restoration Agreement (KBRA)

When considering whether or not to list a species, NMFS is not to consider promised, pending or future management actions, but instead only the current management and status of the species. In numerous ESA listing cases, the USFWS has been forced by judicial action to reverse decisions not to list species because they relied on promised management actions; this includes decisions over the Barton Spring's salamander, Queen Charlotte goshawk, jaguar, Alexander Archipelago wolf, and coho salmon. It is imperative that NMFS consider only the current management and species status. States, federal agencies, and private interests can easily promise to protect and recover species in order to avoid or delay a potentially controversial listing; unfortunately, there are not means to ensure management agencies will follow through on promises, or that their actions will result in recovery. To protect species from ongoing destruction, modification or curtailment of habitat or range, listing under the ESA is required while management actions are being tested. If promised management actions result in substantial recovery, then such actions should be incorporated into a recovery plan for the species.

In response to the noted court decisions on various species' listings, USFWS developed a policy for evaluating the contribution of conservation efforts while considering the potential need for listing. This policy identifies criteria for determining the certainty a conservation effort and whether it is likely to be effective. (68 Fed. Reg. No. 60, 28 Mar. 2003). We have considered this policy when evaluating pending agreements in the Klamath Basin, and understand that NMFS should do the same when considering listing of the Upper Klamath Chinook salmon. Clearly, the Upper Klamath Chinook, particularly the spring run component, is experiencing ongoing threats, placing it in danger of extinction and thus requiring protection as an endangered species, regardless of pending, untested, or promised management actions.

Negotiations regarding the KBRA-KHSA package have occurred as part of FERC's dam relicensing process for over five years, and several drafts of the agreement have been released during this time. The Bureau of Reclamation, in charge of water diversions for the Klamath Irrigation Project in the Upper Klamath Basin has been involved in negotiating and drafting the agreements among stake holders. The final package was signed in February 2010, but awaits legislation and funding ($1.1 billion) in U.S. Congress. The purpose of the KHSA package is to consider the potential removal of four PacifiCorps dams on the Klamath River; the related KBRA is designed to potentially apportion Klamath River water. As required under the ESA, these agreements address listed threatened and endangered species including the coho salmon, Lost River and shortnose suckers and bull trout. The KBRA also includes a reintroduction plan for Chinook salmon into Upper Klamath Lake and its tributaries. The KBRA does not include a completed drought management or climate change plan.

Despite the plans' intentions to address Chinook salmon recovery in the Basin, neither the KHSA nor the KBRA have been legislated, approved by U.S. Congress, nor has funding been appropriated. These proposed plans should not be considered an existing mechanism to protect Upper Klamath Chinook in general or the spring run in particular. All mechanisms to address stream flows are designed for the specific life history and biology of ESA listed coho salmon, not for Chinook in the region.

Even if the agreement were to be approved, it would not effectively protect Chinook salmon in the Basin. First, funding for restoration is not certain and even with successful legislation, it is unclear where funding to protect Chinook salmon would come from. Furthermore, dam removal would not begin for a full 9-10 years and the process of removal and river recovery would not be completed until several years after that. Chinook salmon populations are threatened to the point that protections cannot be delayed. Also, the current agreement lacks a plan for drought years so that in particularly dry years, salmon would receive no protections. The deal guarantees water for irrigation but not for fish and wildlife, which undermines ESA protections for coho in drought years. Finally, The ESA protections which do apply to coho will not necessarily protect Chinook because of their differences in run timing.

State Regulatory Mechanisms: TMDL

State mechanisms which affect Upper Klamath Chinook and their habitat include the establishment of Total Maximum Daily Loads (TMDLs) for chemical pollution in the Klamath River. The Klamath River is listed as a water quality impaired river under Section 303(d) of the Clean Water Act and as required by the Act, states are required to establish TMDLs for instate impaired waterways. Enforceability of TMDLs is difficult and insufficient. The continued occurrence of dangerous algal blooms in reservoirs in this river system clearly illustrates the inadequacy of this regulation. Federal regulators recently adopted new TMDLs calling for a 57% reduction in phosphorous and a 32% reduction in nitrogen and a 16% cut in carbonaceous biochemical oxygen from wastewater. Although the new TMDLs are intended to protect salmon resources, there are no implementation programs in place for controlling pollutant inputs from land use. Without these implementation plans, standards are unlikely to be met.

State Regulatory Mechanisms: Mining

California instated a ban on suction dredge mining in 2009 in response to a lawsuit from the Karuk tribe referencing damage to fish habitat and water quality. This ban is clearly beneficial for Upper Klamath Chinook. However, the ban is temporary until the California Department of Fish and Game completes an environmental review of suction dredge mining. There is no guarantee that this mining practice will not be reintroduced after the environmental review occurs.

Federal and State Regulatory Mechanisms: Fishing

Fishing harvest allocations are decided annually based on input from federal, state, regional, and tribal bodies. In general, tribes maintain the right to fifty percent of the total annual harvest. Within tribal and non-tribal fishing, further allocations are assigned for commercial ocean fisheries, sport, and subsistence fishing. Harvest quotas are based on projections for run size each year and attempt to maintain a minimum spawning escapement of 35,000 fish to protect the runs for the long-term. Overfishing is an aggravating factor to the grim future of Upper Klamath Chinook; fishing regulations alone will not provide for the continued existence of this ESU. In recent years, projections have overestimated the number of salmon to return to the Basin; this has resulted in overfishing.

Federal and State Regulatory Mechanisms: California Forest Practices Rules

California Forest Practices Rules are developed under the California Forest Practices Act of 1943 which governs logging practices on all private lands. These rules are inadequate to prevent harm to Upper Klamath Chinook.

Regulatory Mechanisms: Climate Change

Current global, national, and state climate change legislation and agreements are entirely inadequate to prevent ocean acidification and the variability of other ocean conditions aggravated by climate change. As noted, these conditions pose a significant threat to the long-term survival of salmonids in their marine environment.

Greenhouse gas emissions and resulting climate change is among the least regulated threats to Upper Klamath Chinook. The primary international regulatory mechanisms addressing greenhouse gas emissions and global warming are the United Nations Framework Convention on Climate Change, the Kyoto Protocol, and the Copenhagen Accord. While the entering into force of the Kyoto Protocol on February 16, 2005 and the development of the Copenhagen accord in December, 2009 mark significant partial steps towards the regulation of greenhouse gases, they do not and cannot adequately address the impacts of global warming that threaten the Upper Klamath Chinook.

Choices about emissions now and in the coming years will have far-reaching consequences on the magnitude of climate change impacts. The longer greenhouse gas emissions reductions are delayed, the more severe the global impacts will be (Karl et al. 2009). If global warming is going to be limited to 2°C above pre-industrial values, global emissions need to peak between 2015 and 2020 and then decline rapidly (Allison et al. 2009). This will require average annual per-capita emissions to shrink to under one metric ton CO_2 per capita. This is 80-95% below the per capita emissions in developed nations in 2000 (Allison et al. 2009).

There are currently no legal mechanisms regulating greenhouse gases on a national level in the United States. The immediate reduction of greenhouse gas pollution is essential to slow global warming and ultimately stabilize the climate system in order to maintain and restore Upper Klamath Chinook habitat.

For the reasons discussed, existing and proposed regulatory mechanisms are indisputably inadequate to ensure the continued survival of the Upper Klamath Chinook salmon.

E. Other natural or human-made factors

Ocean conditions

Ocean conditions have long been associated with the variability of salmon runs. However, recent observations of trends in marine conditions and their effects on salmon suggest that ocean condition variability is becoming a more prominent threat to Upper Klamath Chinook, particularly when combined with other factors (Moyle et al. 2008).

In 1998, NMFS produced an assessment of factors contributing to the decline of west coast Chinook salmon. NMFS cited numerous sources linking climate conditions to ocean conditions and in turn, to salmonid survival and abundance. For example, climatic conditions can change prevailing currents and therefore the ocean productivity associated with nutrient-rich cold water shifts (NMFS 1998). These shifting ocean currents named “El Niño” or “La Niña,” can produce widely varied cycles of productivity (Spence et al. 1996).

El Niño is commonly cited as a cause of decline for west coast Chinook salmon. It is an environmental condition characterized by an unusual warming of the Pacific Ocean off of South America and is caused by atmospheric changes. The warm water current approaches the coast and is reflected north and south along the continents, eventually reaching the coast of North America. El Niño years are characterized by particularly warm sea surface temperatures and changes in coastal currents and upwelling. Changes to the ecosystem include decreased primary and secondary production and changes in prey and predator species distributions and dynamics (NMFS 1998). These changes are detrimental to salmonid survival in the marine environment.

Historically, salmonid populations have been able to persist despite natural cyclical ocean conditions. Years of low productivity have been followed by years of higher productivity, resulting in a relatively balanced overall dynamic. However, NMFS (1998) contends that “the combination of tremendous freshwater habitat loss, and extremely small anadromous salmonid populations has caused these fish to be more vulnerable to extirpation arising from natural events.”

In addition, climate change can be expected to change ocean conditions, thereby affecting Chinook salmon populations. Several studies suggest that these changes are likely to be detrimental to salmon populations; one such study establishes a correlation between climate and Chinook salmon abundance from approximately 1970-1990 indicating that the marine environment has contributed to the variability and decline of Chinook salmon returning to the Columbia River (Francis and Sibley 1991).

Ocean absorption of carbon dioxide, which we know to be on the rise, causes ocean acidification. The Intergovernmental Panel on Climate Change establishes that this phenomena is currently occurring and is projected to continue as well as increase within this century, causing a decrease in surface-water pH of about 0.4 by the end of the century (Feely et al. 2008). Among other likely effects to north Pacific salmonids, ocean acidification may cause substantial changes in overall calcification rates for many species of marine calcifiers including pteropods, which are a major food source for juvenile salmon (Feely et al. 2008). A loss of abundance of salmonid food sources will translate into decreased abundance of north Pacific salmonids.

In 2009, NOAA produced a review (Lindley et al. 2009) to address causes of the 2008 Sacramento River fall Chinook stock collapse. The report identified poor ocean conditions related to upwelling and sea surface temperature as a proximate cause of the collapse, as it led to starvation of salmon entering the ocean in 2005 and 2006. Schwing et al. (2005) conducted a survey in May 2005 on Chinook salmon stomach contents off the coast of California and found most empty. Only 1 of 120 contained krill and none contained juvenile rockfish. This study identified shifts in ocean productivity, in combination with other anthropogenic effects, as a significant cause of the recent low escapement of Sacramento River fall Chinook. The report also recognized that the “rapid and likely deterioration in ocean conditions is acting on top of a long-term, steady degradation of the freshwater and estuarine environment” (Lindley et al. 2009).

While in 2008, sea surface temperatures dropped significantly and led to a high copepod biomass (NOAA 2010), the summer of 2009 brought significant warming and poor ocean conditions, leading to detrimental changes in the pelagic food web and the likely high mortality of juvenile salmonids (NOAA 2010). Clearly, it is the combination of ocean and climate conditions, in addition to strained habitat upstream that create a variety of potentially harmful impacts on salmon.

Ocean conditions are a significant factor in the health and variability of salmon runs and Klamath Chinook are no exception. Ongoing climate change will increase the variability of ocean conditions and without ESA protections, Upper Klamath Chinook populations may not persist through these shifts.

Hatcheries

Hatcheries were developed in the Klamath-Trinity River Basin in an effort to mitigate destruction of habitat by dams. Although artificial propagation has supplemented returns and increased prospects for fisheries, the overall effects have included further damage to runs in this Basin and a reduction in the long-term sustainability of these runs. Hatcheries have likely influenced life history characteristics and diversity. Large numbers of hatchery fish affect wild juvenile Chinook through competition, predation, and disease transmission and wild populations are threatened with reduced fitness through interbreeding with hatchery fish (Moyle et al. 2008). Hatcheries are considered by multiple reviewers to be a high risk for both spring and fall Upper Klamath Chinook (NMFS 2009, J. Katz, pers. comm. 2010).

Hatcheries have operated in the Klamath River Basin since the turn of the century. The first artificial propagation occurred in the Basin in 1896 when over a million Chinook salmon fry were introduced into the Klamath River from the Sacramento River (Snyder 1931). This was followed by more introductions of hatchery fish sourced from the Trinity River, Sacramento River and Redwood Creek (Snyder 1931). By 1916, nearly 17 million Chinook salmon fry had been released into the Klamath River Basin (Cobb 1930 as cited in Myers et al. 1998).

Today, The Iron Gate and Trinity River hatcheries produce Chinook salmon in the Basin. Iron Gate Hatchery was constructed in 1966 just downstream of Iron Gate Dam to mitigate for salmon runs lost through the construction of this dam. The Iron Gate Hatchery has been supplied with eggs mainly from adult Chinook returning to the hatchery and has primarily produced fall run Chinook. Early efforts to maintain a spring run failed and were abandoned in the 1970s (Myers et al. 1998). The Trinity River Hatchery was built in 1963 to supplement runs that had been damaged or destroyed by the construction of Lewiston Dam and this hatchery has maintained both spring and fall runs of Chinook salmon. The Trinity River hatchery also has obtained eggs from within the Basin and primarily from adult Chinook returning to the hatchery.

Every year, between seven and twelve million hatchery-produced juveniles are released into the Basin from the Trinity River and Iron Gate hatcheries (NRC 2004). Surveys of juveniles captured in-river have shown a significant portion of the population to be derived from hatcheries. Between 1997 and 2000, an average of 61% of the juveniles captured at the Big Bar outmigrant trap were hatchery origin fish and 53% and 67% of the Chinook captured in the spring and fall respectively, at the Willow Creek trap on the Trinity River were hatchery fish (Moyle et al. 2008). The proportion of total annual escapement that returns to hatcheries is increasing, from 18% in 1978-1982 to 26% in 1991-1995 and 29% in 2007 (Moyle et al. 2008). Myers et al. (1998) estimate that roughly the same proportion of hatchery fish spawn naturally as return to the hatcheries, suggesting that hatchery-origin fish make up a major component of Chinook salmon in the Basin. In the estuary at the mouth of the Klamath River, about 40% of the juvenile fish were estimated in 2000 to be of hatchery origin (CDFG, unpublished data 2000) and Moyle (2008) asserts that this is a fairly typical figure.

As salmon populations in the Klamath-Trinity River Basin become dependent on artificial propagation, their long-term viability is threatened. An Independent Scientific Advisory Board (ISAB) report in 2005 addressed the viability of ESUs that contain multiple life histories (Bilby et al. 2005). In a population that is integrated with both natural and hatchery salmon, naturally spawning fitness may be depressed and this low replacement rate will last for a number of generations after integration ends. The available evidence suggests that declines in fitness occur rapidly with hatchery culture and that substantial declines occur after only a few hatchery generations (Bilby et al. 2005). The ISAB found further that there is “little evidence of self-sustaining natural populations in integrated hatchery/natural systems.” The presence of hatcheries directly threatens the fitness of wild populations.

Apart from the Salmon River, populations of spring run Chinook are entirely dependent on hatchery-produced individuals suggesting that the Trinity River hatchery has a significant effect on this run. Hatchery-reared spring Chinook face genetic, ecological and sustainability problems as the persistence of the run comes to depend on the existence of artificially propagated fish.

Genetic problems resulting from the presence of hatchery fish have been cited by several sources (Bilby et al. 2005, Moyle et al. 2008, NOAA 2006). Spring run Chinook spawning below the current hatcheries are likely to hybridize with fall Chinook, directly threatening the persistence of the distinct spring run in the Basin. Within the spring run in the Trinity River, fish entering freshwater late in the season are apparently largely of hatchery origin (NRC 2004) and given the late timing, it is unclear if these fish are sexually mature and able to breed with fish already in the Basin. These fish may be the result of hybridization between spring and fall run Chinook due to hatchery practices (Moyle et al. 2008). The historical importation of eggs from outside the Basin for hatchery use has also likely weakened the genetic fitness of fish adapted to the Basin. The current practice of collecting eggs from fish returning to the hatchery results in a narrowed gene pool, potential inbreeding (NOAA 2006) and the resulting damage to the genetic sustainability of both spring and fall run Chinook salmon in the Basin.

Hatchery fish also lead to ecological problems related to competition, predation, disease, and overfishing of wild Chinook salmon stocks (Moyle et al. 2008). Competition from hatchery juveniles has been documented to cause Chinook declines, resulting in low survival of both wild and hatchery juvenile salmonids (Higgins et al. 1992, NRC 2004). Predation of wild-spawned juveniles occurs from larger juveniles released from hatcheries (NRC 2004). Disease outbreaks occur in hatcheries and have included epidemics of IHN and BKD at the Trinity River Hatchery (Higgins et al. 1992, Moyle et al. 2008) and once released, fish can transmit disease to wild fish (NOAA 2006). Also, hatcheries cause overfishing of wild salmon because the size of the harvest that is sustainable for an integrated population harms wild fish populations. The magnitude of sustainable harvest that is extracted from an integrated hatchery and naturally spawned salmon population has been connected to the probability and magnitude of depression in natural spawning fitness in these integrated populations (Bilby et al. 2005).

After hatchery integration ceases, it is questionable whether the wild spawning component of that population will be able to recover. Although there is potential for a wild population to readapt to the natural environment after a hatchery program is terminated (Lynch and O’Healy 2001; Goodman 2004, 2005), success is dependent on a number of factors. Readaptation must occur rapidly enough to offset the poor productivity caused by integration (Bilby et al. 2005). In examples of attempts to reintroduce wild spawning coho, spring and fall run Chinook and chum salmon in the Columbia Basin, the reestablishment of self-sustaining populations was found to be the exception rather than the rule (Bilby et al. 2005). Success depends on also addressing ecological, habitat, overharvest and adaptation problems.

Upper Klamath Chinook, and particularly spring run Chinook have come to be dependent on artificial propagation in the Basin. The long history of hatchery practices has resulted in a spring run that is unlikely to persist naturally unless significant management actions are taken to reestablish healthy wild-spawning populations.

Climate Change

A recent collaborative report by the Forest Service, the University of Oregon and the National Center for Conservation Science and Policy details projected changes to the Klamath Basin as a result of climate change. Climate models consistently suggest that the net effect of climate change on Upper Klamath Basin habitats and populations will be negative, as water levels both drop and become more variable, and stream temperatures rise (Barr et al. 2010).

By the year 2100, human-caused global climate change is, depending on regulatory actions, estimated to raise global temperatures from 1.1 to 6.4°C (Barr et al. 2010). The Klamath Basin is generally dry and climate change is expected to exacerbate this status (Barr et al. 2010). Predictions of yearly precipitation are variable under different models. Even so, all models agree that warm season precipitation will decline (Barr et al. 2010).

Although summer flows are already extremely low in the Klamath Basin due to irrigation, further decline in summer flows can be expected through decreased summer precipitation and warmer air temperatures year-round. As mean annual temperatures increase, more precipitation during the fall, winter, and spring will fall as rain rather than snow, reducing snowpack and limiting water stored as snow for release during warm summer months (Barr et al. 2010). The shorter snowpack melt season will also result in unsuitable perennial side channel and floodplain habitats that are currently used by Upper Klamath Chinook (Barr et al. 2010).

The natural hydrograph of Klamath Basin rivers and streams will be further altered under climate change conditions as flood events increase (Barr et al. 2010). Higher rates of peak flows will occur during the winter and scour streambeds, killing Chinook eggs. The National Academies of Science has estimated a much higher rate of Chinook egg mortality as temperatures warm.

Lower flows, particularly in combination with higher air temperatures and lower rates of snowmelt, will result in higher stream temperatures (Barr et al. 2010). As previously described, higher stream temperatures have a wide variety of negative effects on Upper Klamath Chinook including increased disease vulnerability and presence, lower levels of dissolved oxygen, and increased mortality.

Climate change and resulting higher temperatures will affect water quality in other ways as well. Harmful algal blooms are expected to take place earlier, last longer, and occur at higher intensities (Barr et al. 2010). Harmful algal blooms often release toxins which are dangerous to both fish and land animals, and further decrease levels of dissolved oxygen in the water.

Climate change is also predicted to cause increased sediment levels (Barr et al. 2010) in the region. As storm events become more frequent and intense, and as more precipitation during the winter falls as rain rather than snow, streams will receive more eroded fine sediment (Barr et al. 2010). Higher levels of nutrients deposited through erosion will increase algal blooms. Sediment deposition will lead to suffocation of Chinook eggs and alevins. Increased sediment will also lower the productivity of streams overall, as clarity decreases and less light reaches necessary primary producers (Henley et al. 2000), decreasing the life the stream can support.

Flows from springs fed by groundwater are likely to decline due to climate change, with some smaller springs potentially disappearing completely (Barr et al. 2010). As these flows are often cooler than main stem river flows, temperatures will continue to increase and essential cold-water refuges for fish will be further limited (Barr et al. 2010). Furthermore, as the region's agriculture becomes increasingly dependent on groundwater for irrigation, as seen during the

2010 drought, there will be less groundwater recharge and supplemental flow into regional rivers.

Changes to ocean conditions due to climate change will also threaten Upper Klamath Chinook. Climate variability plays an important role in the inter-annual variation in abundance of Pacific salmon stocks. Lindley et al. (2009) observed a trend over the past several decades of increasing variability in climate indices related to salmon survival. Although this affects salmon throughout the coast region, populations near the southern end of their range and with low abundance and little life-history diversity off the California coast may be more vulnerable to extreme climatic fluctuations. If climate variability continues, increasing as a result of climate change, more extreme variation in salmon stocks is likely. Similarly, already-reduced salmon stocks in the Klamath-Trinity River Basin may not persist through these extremes (Lindley et al. 2009).

Apart from the direct effects of climate change on water ecosystems, terrestrial ecosystems will also be affected in the Klamath River region. It is very possible that as precipitation and temperature patterns change, redwood and spruce tree communities will decline or disappear (Barr et al. 2010). This, in turn will affect Upper Klamath Chinook habitats, as the large woody debris that create important holding pools for the fish may decline. Range shifts may happen rapidly, facilitated by disease and insect outbreaks, as well as increased rates of wildfires, which are expected to increase due to warmer winters and lower water levels in the summer (Barr et al. 2010).

Climate change is also expected to have widespread effects on terrestrial ecosystems that may end up changing the ecosystem to such a degree that Chinook populations are negatively impacted. For example, noxious, invasive species will likely increase in abundance, and it is possible that some species of plants and animals will decrease greatly (Barr et al. 2010). Species relationships may be disrupted as timing behavior shifts. Finally, it is likely that wetlands and riparian habitats will decrease generally (Barr et al. 2010), which could result in less viable Chinook habitat, and a possible increase in competition and predation for Upper Klamath Chinook.

Over the next several decades, the effects of climate change will be strongly felt in the Klamath-Trinity River Basin. Rivers, streams, and their inhabitants will be particularly affected, and Upper Klamath Chinook require strong protective management actions in order to withstand these changes.

V. Critical habitat should be designated for the Upper Klamath Chinook

Critical habitat is defined by Section 3 of the ESA as:

> (i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and

(ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species. 16 U.S.C. §1532(5).

Therefore, critical habitat should ensure an adequate amount of protected habitat in a spatial configuration that allows for the long-term survival and recovery of the species, including a network of interconnected reserves that provide for self-sustaining populations, genetic interchange, migration and dispersal. These are basic tenets of conservation biology.

The designation and protection of critical habitat "provide[s] a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." 16 U.S.C. §1536(a)(2). The designation of critical habitat provides listed species with additional protections under Section 7 of the ESA. The Section 7 consultation requirements provide that no action authorized, funded, or carried out by any federal agency will "jeopardize the continued existence of any endangered species or threatened species *or result in the destruction or adverse modification of [critical habitat]*." 16 U.S.C. §1536(a)(2) (emph. added). A more scrutinizing level of consultation is conducted when habitat is designated as "critical." If critical habitat is involved in the consultation, the project must not impede recovery of the species. In comparison, a project that may affect a species' occupied habitat that is not officially designated as "critical habitat" must only show that its impact on that habitat will not jeopardize the continued existence of the species.

Critical habitat designation also protects species by helping to define the meaning of "harm" under Section 9 of the ESA, which prohibits unlawful "take" of listed species, including harming the species through habitat degradation. Although "take" through habitat degradation is not expressly limited to harm to "critical habitat," it is practically much easier to demonstrate the significance of the impact to a species' habitat where that habitat has already been deemed "essential," or "critical," to the species' continued survival. *See Palila v. Hawaii Department of Land and Natural Resources*, 852 F. 2d 1106 (9th Cir. 1988).

Critical habitat also helps species by providing for agency accountability through the citizen suit provision of the Act. The citizen suit provision permits members of the public to seek judicial review of the agency's compliance with its mandatory statutory duty to consider the habitat needs of imperiled species. Also, the designation of critical habitat provides valuable information for the implementation of recovery plans.

Endangered Species Act "critical habitat" protections are a crucial tool to recover endangered species. A peer-reviewed study in the April 2005 issue of BioScience, "The Effectiveness of the Endangered Species Act: A Quantitative Analysis," concludes that species with critical habitat for two or more years are more than twice as likely to have improving population trends than species without.

In sum, critical habitat is a separate and additional requirement of the Act that provides important protections for listed species not otherwise provided by law.

VI. Processing of this Petition

This petition is submitted under the provisions of the ESA, 16 U.S.C. §§1531 et seq., 50 C.F.R. 424.14, and the APA, 5 U.S.C. §533. As a petition to revise critical habitat, NMFS is bound to process this petition within a predetermined time frame as defined by CFR 424.14(c) to the maximum extent practicable. The regulations require NMFS to make a finding within 90 days of receipt of this petition as to whether the petition presents substantial scientific information indicating that the revision may be warranted. The finding shall be promptly published in the Federal Register. 50 CFR 424.14(c)(1). Within 12 months of receiving this petition, NMFS is required to determine how it will proceed with the requested revision, and shall promptly publish notice of such intention in the Federal Register. 50 CFR 424.14(c)(3). Petitioner fully expects NMFS to comply with these mandatory deadlines.

For all petitioners:

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