KERN RIVER RAINBOW TROUT
***Oncorhynchus mykiss gilbertii* (Jordan)**

Critical Concern. Status Score = 1.4 out of 5.0. The Kern River rainbow trout has a high probability of disappearing as a distinct entity in the next 50-100 years, if not sooner. The greatest threat continues to be hybridization with coastal rainbow trout, but competition and predation from invasive brown trout and brook trout may also be contributing to its decline.

Description: This subspecies is similar to coastal rainbow trout but its coloration is brighter, with a slight tinge of gold; it has heavy, fine spotting over most of its body (Moyle 2002). The spots are more irregular in shape than those of the round spots of the other two Kern basin golden trouts. On many larger fish, there is a broad rosy-red band along the sides. There are also minor differences in meristics from the other two golden trouts (Schreck and Behnke 1971).

Taxonomic Relationships: The taxonomic status of this subspecies is controversial because of its complex evolutionary history and exposure to introduced varieties of rainbow trout. In 1894, D. S. Jordan designated this fish as a distinctive subspecies of rainbow trout; this analysis was accepted until Schreck and Behnke (1971) described it as a population of golden trout. Their decision was based mostly on comparisons of lateral scale counts and on aerial surveys that led them to believe that there were no effective barriers on the Kern River which might have served to isolate trout in the Kern River from those in the Little Kern River [in particular, barriers to downstream movement of golden trout into the Kern River, which also applies to Golden Trout Creek]. However, in a subsequent analysis, Gold and Gall (1975) determined that golden trout populations were effectively isolated genetically and physically. Meristic (Gold and Gall 1975) and genetic (Berg 1987) characteristics of *O. m. gilbertii* were regarded as sufficiently distinctive to warrant its subspecific status (Berg 1987). Bagley and Gall (1998), using mitochondrial and nuclear DNA, found that the Kern River rainbow was distinctive, but probably originated as the result of an early (natural) invasion of coastal rainbow trout that hybridized with Little Kern golden trout, creating a new genome. This has been more or less confirmed by analysis of genetic variation by Amplified Fragment Length Polymorphism (AFLP) markers for populations of rainbow trout statewide (M. Stephens 2007). The AFLP analysis indicated that Kern River rainbow trout represent a distinct lineage that is intermediate between coastal rainbow trout and Little Kern golden trout, although there was also some evidence of recent hybridization with coastal rainbows, presumably of hatchery origin. Most recently, Erickson (2013), using single nucleotide polymorphism (SNP) and microsatellite markers found Kern River rainbow trout to be most closely related to California golden and Little Kern golden trout, relative to numerous rainbow trout hatchery strains and a coastal rainbow trout reference population.

Life History: No life history studies have been performed on this subspecies, but its life history is assumed to be similar to other rainbow trout populations in large rivers (e.g., Moyle 2002). Historically, fish found in the mainstem Kern River grew to large sizes, as much as 71 cm TL and 3.6 kg (Behnke 2002), although fish over 25 cm TL are rare today (S. Stephens et al. 1995).

Habitat Requirements: Little information is available on Kern River rainbow trout but, in general, their habitat requirements are likely similar to other rainbow trout, with some

modifications to reflect the distinctive environment of the upper Kern River (Moyle 2002). Environmental tolerances are presumably similar to those of coastal rainbow trout.

Distribution: This subspecies is endemic to the Kern River and its tributaries in Tulare County. It was once widely distributed in the system; in the mainstem it probably existed downstream well below where Isabella Dam is today and upstream in the South Fork as far as the town of Onyx (S. Stephens et al. 1995). It has been largely extirpated from the Kern River at least downstream from the Johnsondale Bridge (ca. 16 km above Isabella Reservoir). Today, remnant populations exist in the Kern River above Durrwood Creek, in Rattlesnake and Osa creeks, and possibly upper Peppermint Creek (S. Stephens et al. 1995). Bagley and Gall (1998), used a variety of genetic techniques to determine that several populations, mostly located in the middle section of the Kern River drainage, were relatively unhybridized Kern River rainbow trout: Rattlesnake Creek (in Sequoia National Park), Kern River at Kern Flat, Kern River above Rattlesnake Creek, Boreal Creek, Chagoopa Creek, Kern River at Upper Funston Meadow, Kern River above Redspur Creek, and Kern River at Junction Meadow. These populations are in the middle of the historical range and lack hybridization with either California golden trout (seen in the upper sections of the Kern) or with coastal rainbow trout (seen in the lower sections). While Behnke (2002) doubted that pure Kern River rainbow trout still exist in their native range, recent genetic analyses suggest that at least some unhybridized populations exist as indicated above. Erickson et al. (2010) and Erickson (2013) found seven populations that exhibit low introgression (estimates of less than 10%) and a few populations exhibit introgression of less than 2%. Nearly all of these populations occur in headwater tributaries that have been reproductively isolated from downstream, and in some cases, heavily introgressed populations. Much of their remaining habitat is in Sequoia National Forest (29+ km) and Sequoia National Park (40+ km). In addition, there are distinctive introduced populations in the Kern-Kaweah River and Chagoopa Creek, which have maintained their genetic identity (M. Stephens 2007, Erickson 2013).

Trends in Abundance: Kern River rainbow trout were once abundant and widespread in the upper Kern Basin. As a result, they were subject to intensive removal by angling. Since the 19th century, overexploitation, combined with habitat degradation and, most importantly, hybridization with other trout, has reduced populations to a small fraction of historical numbers. In 1992, a study of Kern River rainbow trout abundance in the Kern River in Sequoia National Park indicated there were about 360-840 trout per km (600-1,400 trout per mile) of all sizes (Stephens et al. 1995). Snorkel survey data collected by the Department of Fish and Wildlife in October of 2009 indicated there were about 32-2,145 trout per km (51-3,452 trout per mile) over multiple surveyed reaches on the Kern River (DFW Wild and Heritage Trout Snorkel Survey data set 1994-2012). However, the genetic status of these fish and potential estimates of introgression are unknown. There are no abundance data on unhybridized or minimally introgressed Kern River rainbow trout populations but, if it is assumed they currently persist in 20 km of small streams, with 200-1,500 trout per km, the total numbers would be 4,000-30,000 fish. These estimates are highly questionable given natural variation in numbers, difference in survey methods, small sample sizes upon which they are based, and uncertainties regarding the actual distribution of Kern River rainbow trout and their respective levels of introgression. The estimates do, however, suggest that absolute numbers in the wild are low and vulnerable to reduction by natural and human-caused events. The majority of the least hybridized populations

are isolated from other populations, as shown in recent genetic assays (Erickson 2013). Thus, the status of Kern River rainbow trout could deteriorate rapidly due to their lack of population connectivity as populations disappear or become heavily hybridized.

Factors Affecting Status: The largest threat to Kern River rainbow trout is the introduction of other trout strains (coastal rainbow, California golden, Little Kern golden trout) and the loss of Kern River rainbow trout genetic material due to hybridization (Erickson et al. 2010). Erickson (2013) performed a detailed genetic analysis of upper Kern Basin trout in the historical range of Kern River rainbow trout using single nucleotide polymorphism (SNP) and microsatellite markers to evaluate the extent of introgression, and found that introgression with coastal rainbow trout and California golden trout was prevalent throughout the basin, but much less so for Little Kern golden trout. Many of the lower basin tributary populations were heavily introgressed with coastal rainbow trout. California golden trout introgression was also apparent in lower portions of the Kern basin and some sites in the upper basin. Erickson et al. (2010) and Erickson (2013) attributed high levels of hybridization with both coastal rainbow and California golden trout to well documented hatchery stocking in the past. Of the populations studied, Erickson et al. (2010) and Erickson (2013) found seven Kern River rainbow trout populations that showed low or extremely limited hybridization, scattered among creeks and lakes in the upper Kern Basin or nearby basins (from introductions). These populations generally exhibited less than 10% introgression estimates and showed strong similarities to the Kern River rainbow trout genetic reference. The Nine Lakes North population, in addition to Kern-Kaweah River and Picket Creek populations, represents the best examples of Kern River rainbow trout due to extremely low introgression estimates and a high number of Kern River rainbow trout-specific alleles (Erickson et al. 2010, Erickson 2013). While reproductive isolation has played an important role in minimizing hybridization in a few populations within the basin, those same populations show limited genetic diversity because of a lack of population connectivity and from genetic bottlenecks associated with founder effects (Erickson 2013). In addition to the aforementioned populations, Erickson (2013) also found another 14 populations that showed a distinct Kern River rainbow trout genetic signature with varying degrees of hybridization.

The primary threats to remaining populations are identical to those facing other endemic trout of the southern Sierra, which center on interactions with non-native trout: (1) hybridization with hatchery rainbow trout, which are still planted in the upper Kern Basin, though not in Sequoia National Park, (2) hybridization with golden trout historically planted (particularly California golden trout), that may continue moving into their waters, (3) low genetic diversity affecting the ability of relatively unhybridized populations to adapt to changing conditions and (4) competition from brown, brook, and hatchery rainbow trout. Invasions by hatchery rainbow trout or by brown or brook trout into the remaining small, isolated streams are possible, especially through angler-assisted introductions. In addition, habitat loss from the region's long history of grazing, logging and roads, as well as stochastic events such as floods, drought and fire can degrade habitats, negatively affecting already isolated populations and their persistence (Moyle 2002). For a full discussion of these shared regional stressors in the Kern Basin, see the California golden trout account.

Factor	Rating	Explanation
Major dams	Medium	Isabella Reservoir has fragmented the species' range and allowed for introduction of alien species.
Agriculture	n/a	
Grazing	Medium	Pervasive in the area, although less severe than in the past.
Rural /residential development	Low	Few residences; most of the subspecies' range is within Sequoia National Forest or Sequoia National Park lands.
Urbanization	n/a	
Instream mining	n/a	
Mining	n/a	
Transportation	Low	Trails and off-road vehicle routes can be a source of sediment influx into streams; however, most of range is in areas with minimal transportation impacts.
Logging	Low	This is an important land use in the region but probably has little direct effect on local streams.
Fire	Low	Fish-killing fires are unlikely given the sparse plant communities in the Kern Basin; fires are generally allowed to burn in national parks with unknown impacts to fish populations.
Estuary alteration	n/a	
Recreation	Medium	Off road vehicles a potential threat, but more so in past.
Harvest	Medium	Heavily harvested in past; present harvest, legal and illegal, may affect some populations.
Hatcheries	High	Constant threats of introgression, competition and predation from hatchery fish.
Alien species	Critical	Non-native trout limit distribution via hybridization, competition, predation and possible disease transfer.

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

Effects of Climate Change: The major predicted impacts from climate change in the range of the Kern River rainbow trout are a reduction in snow pack due to warmer temperatures, as well as a seasonal shift in peak runoff to the early spring. However, the southern Sierra Nevada is the highest part of the mountain range, and this may offset substantial reductions in snowpack, as is predicted in the northern Sierra Nevada and other regions of the state. Thus, snowmelt is likely to maintain flows in Kern River rainbow trout streams, but the timing and volume of these flows may shift over time. Nevertheless, more precipitation may come as rain, potentially earlier in the

season, which may lead to increased 'rain on snow events' and corresponding flash flooding. This may be particularly acute in the Kern River, which drains a large watershed area and may suffer substantial habitat alteration or degradation associated with flood events. Since snowpack is predicted to melt earlier in the season, meadows and forests surrounding Kern River rainbow habitats are likely to become drier by the end of summer, with reduced streamflows. Elimination of grazing and other activities that compact meadows (reducing their ability to store water) and reduce riparian cover and shade may mitigate, in part, the predicted effects of climate change. Temperatures in streams are likely to increase, and it is possible that spawning may occur earlier, with unknown consequences. For these reasons, Moyle et al. (2013) list wild populations of Kern River rainbow trout as "critically vulnerable" to extinction via climate change, assuming the small, isolated, first- and second-order streams that support most populations with little introgression would be subject to increased frequency and extent of drying and warmer temperatures. Kern River rainbow trout occupying the main stem Kern may be less subject to threats of habitat loss due to drying but may be negatively affected by flood-based habitat degradation, warmer water temperatures, lower flows, and other factors.

Status Score = 1.4 out of 5.0. Critical Concern. The Kern River rainbow trout has a high probability of disappearing as a distinct entity in the next 50-100 years, if not sooner (Table 2). It is listed as a Special Concern (formerly Category 2) species by the USFWS, indicating that it is a candidate for listing but that there is inadequate information to make the determination. The American Fisheries Society considers it to be "Threatened" (Jelks et al. 2008), CDFW labels it as a "Critical Concern" species in their Fish Species of Special Concern Report (CDFW 2015), while NatureServe considers it as "Critically Imperiled."

Kern River rainbow trout are confined to a handful of streams that are subject to natural and human-caused disturbance, such as landslides and fire, even through most are in protected areas including Sequoia National Park. The greatest single threat to the continued persistence of the species continues to be invasions of alien rainbow trout, brown trout, and brook trout into their remaining streams, either through natural invasions, stocking programs, or through angler-assisted introductions. Protection of remaining populations, therefore, requires constant vigilance and the ability to react quickly to counter new threats.

Metric	Score	Justification
Area occupied	1	Found in 4-6 small tributaries and short reaches of the Kern River.
Estimated abundance	2	High uncertainty about size of populations.
Intervention dependence	1	Barriers must be maintained, planting of hatchery fish managed (preferably eliminated), grazing managed, and other actions.
Tolerance	3	Presumably fairly tolerant as most rainbow trout are but not tested.
Genetic risk	1	Hybridization with introduced rainbow trout and California golden trout a constant high risk to its distinctiveness.
Climate change	1	Rated critically vulnerable in Moyle et al. (2013).
Anthropogenic threats	1	1 Critical, 1 High, and 4 Medium threats.
Average	1.4	10/7.
Certainty (1-4)	3	Least-studied of three native trout found in the Kern River Basin.

Table 2. Metrics for determining the status of Kern River rainbow trout in California, where 1 is a poor value and 5 is excellent. Each metric was scored on a 1-5 scale, where 1 is a major negative factor contributing to status; 5 is a factor with no or positive effects on status; and 2-4 are intermediate values. Certainty of these judgments is moderate. See methods for explanation.

Management Recommendations: A multi-agency management plan for the upper Kern River basin, written in 1995, has as its goal to "restore, protect, and enhance the native Kern River rainbow trout populations so that threatened or endangered listing does not become necessary" (S. Stephens et al. 1995, p. 9). While this plan has been implemented, almost 20 years later the trout may still merit listing. Problems addressed in the plan still exist, including stocking of non-native trout (including hatchery rainbow trout), grazing in riparian areas, and heavy recreational use of the basin, including angling. Future management actions should be based upon recommendations in this plan and updates to address developments in the past two decades should be performed (especially data and other gap analyses). Periodic genetic sampling and abundance and distribution data are needed in order to better assess the current status of the Kern River rainbow trout and establish a baseline from which to monitor trends over time. Erickson (2013) recommends establishing a hatchery broodstock program with strict genetic protocols to improve genetic diversity throughout the basin.

The Edison Trust Fund is supposed to provide at least $200,000 each year to implement the management plan and improve fisheries in the upper Kern Basin, including developing a conservation hatchery for Kern River rainbow trout, increasing patrols of wardens in areas where recreational angling occurs, and funding genetic studies. However, the Trust has not committed these funds to the project in recent years. CDFW will use the conservation hatchery to raise and stock only Kern River rainbow trout in the Kern Basin instead of coastal rainbow trout, which is a significant improvement in stocking practices (J. Weaver, CDFW, pers. comm. 2016).

New References:

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