KLAMATH MOUNTAINS PROVINCE STEELHEAD
Oncorhynchus mykiss irideus

Status: High Concern. Klamath Mountains Province (KMP) steelhead appear to be in long-term decline. Stream-maturing forms (mostly summer steelhead) are more limited in distribution and face a higher likelihood of near-term extinction than ocean-maturing forms (winter steelhead).

Description: Steelhead are anadromous coastal rainbow trout which return from the ocean as large, silvery fish with numerous black spots on their tail, adipose and dorsal fins. The spots on the tail are typically in radiating lines. Their dorsal coloration is iridescent blue to nearly brown or olive. Their sides and belly appear silver, white, or yellow, with an iridescent pink or red lateral band. The mouth is large, with the maxillary bone usually extending behind the eyes, which are above pinkish cheeks (opercula). Teeth are well developed on the upper and lower jaws, although basibranchial teeth are absent. The dorsal fin has 10-12 rays; the anal fin, 8-12 rays; the pelvic fin, 9-10 rays; and the pectoral fins, 11-17 rays. The scales are small, with 110-160 scales along the lateral line, 18-35 scale rows above the lateral line, and 14-29 scale rows below the lateral line (Moyle 2002). The coloration of juveniles is similar to that of adults, except they have 5-13 widely spaced oval parr marks, centered on the lateral line, with the interspaces wider than the parr marks themselves. Juveniles also possess 5-10 dark marks on the back between the head and dorsal fin, which make the fish appear mottled. There are few to no spots on the tail of juveniles and white to orange tips on the dorsal and anal fins. Resident (non-anadromous) adult coastal rainbow trout may retain the color patterns of parr (Moyle 2002). The various forms in California are identical morphologically and are distinguished mainly by genetics, although different populations may show some variation in the average size of returning adults.

Taxonomic Relationships: Until the late 1980s, all steelhead were listed as *Salmo gairdneri gairdneri*. However, Smith and Stearley (1989) showed that steelhead are closely related to Pacific salmon (genus *Oncorhynchus*) and are conspecific with Asiatic steelhead, "*Salmo" mykiss* which had been recognized as a species before the North American form. As a result, rainbow trout, including steelhead, are officially recognized by the American Fisheries Society as *Oncorhynchus mykiss*. Two major genetic groups of *O. mykiss* have been identified as inland and coastal groups, separated by the crest of the Cascade Range (Busby et al. 1994). Coastal rainbow trout of North America, including coastal steelhead, have been identified in the subspecies *O. m. irideus* (Behnke 1992).

Historically, Evolutionarily Significant Unit (ESU) criteria were created by the National Marine Fisheries Service (NMFS) for management of endangered salmonids (56 FR 58612). In 2005, a joint policy with the U.S. Fish and Wildlife Service (USFWS) and NMFS designated Distinct Population Segment (DPS) criteria for steelhead (61 FR 4722). The DPS Policy states that a group of organisms forms a distinct population segment if it is "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors." While the boundaries for designation of a steelhead population as a DPS did not change much from an ESU designation, the DPS designation allowed for the listing of anadromous forms under state or federal endangered species acts, while not listing resident forms (although the two forms can interbreed). Six west coast steelhead DPSs occur within California. The NMFS and CDFW recognize distinct life history variations of steelhead in the KMP DPS, based upon their timing of freshwater entry, reproductive biology and spawning strategy (Busby et al. 1996). These KMP steelhead DPS variations have been defined as: winter, fall and summer, with a distinctive variant known as 'half-pounder,' that may be derived from any of the three DPSs. Genetic data do not support the hypothesis that winter, fall and summer steelhead populations are separate monophyletic units (Reisenbichler et al. 1992, Busby et al. 1994); thus, all life history variations within the KMP DPS are considered a single population source, although there is some degree of genetic differentiation among steelhead groups or clusters within the basin (Pearse et al. 2006, Pearse et al. 2011).

Genetic analyses from samples collected between the Klamath River estuary and the confluence of the Trinity River supports at least two discrete migrating populations, based on timing of freshwater entry (Papa et al. 2007). This correlates with the observed run-timing for the ocean-maturing (winter) and stream-maturing (summer, fall) ecotypes (Table 1). Pearse et al. (2007) analyzed genetic samples collected from 30 sites throughout the Klamath River watershed and three Trinity River sites. Results indicated that geographically proximate populations were most similar genetically. Steelhead sampled from the Klamath River below the Trinity River confluence (Turwar, Blue, Pecwan, Cappell, and Tully creeks) expressed limited gene flow with steelhead sampled upstream of the confluence. Steelhead sampled nearest the mouth of the Klamath River (Blue and Hunter creeks) had genetic similarity to populations in the Smith River and Wilson Creek, showing that migration of nearby coastal stream populations provides a source of additional variation. Populations sampled in the middle regions of the Klamath River basin clustered closely together. However, steelhead from the Shasta and Scott rivers were genetically distinct from steelhead sampled in other mid-Klamath basins and clustered closely to steelhead from Iron Gate Hatchery, suggesting that influence of hatchery gene flow (possibly from straying) to these nearby tributaries has occurred (Pearse et al. 2007). Samples collected from Trinity River Hatchery steelhead clustered most closely with the relatively homogeneous mid-Klamath steelhead, perhaps due to decades of egg transfers from the mid-Klamath basin to the hatchery (Busby et al. 1994). Steelhead from the only in-river collection site on the Trinity River (Horse Linto Creek) grouped with steelhead from the lower Klamath River, below the confluence.

Genetic studies of KMP summer steelhead indicate that they are more closely related to KMP winter steelhead than to summer steelhead outside the KMP (Reisenbichler et al. 1992). Recent genetic studies of summer and winter steelhead show a low level of differentiation between the two runs over multiple years, but also identified potentially greater levels of differentiation between spatially isolated reproductive populations (Papa et al. 2007, Pearse et al. 2007). Genetic studies on steelhead from the Eel River (Northern California Steelhead DPS) also found that winter and summer populations were more closely related to each other than they were to winter and summer populations from other rivers (Clemento 2006). Nevertheless, non-genetic factors (physical, physiological, ecological, and behavioral factors) indicate that the stream-maturing life history is distinct (presumably with a genetic basis) and that these fish are largely segregated from winter steelhead.

Life History: Two basic reproductive strategies have been identified for steelhead: ocean-maturing and stream-maturing. Ocean-maturing steelhead enter fresh water with well-developed gonads and spawn relatively soon thereafter, while stream-maturing steelhead enter freshwater with immature gonads and require several months to mature and then spawn (Burgner et al. 1992, Busby et al. 1996). Ocean-maturing steelhead typically begin spawning migration between November and April and are generally referred to as winter steelhead. Stream-maturing steelhead enter fresh water between May and October and are generally referred to as summer steelhead (Burgner et al. 1992). In the KMP, the term "fall steelhead" is used to distinguish a distinct run that enters fresh water between August and November, whereas summer steelhead enter between April and June. Both summer and fall steelhead are considered stream-maturing and fall steelhead are often lumped with, or described as, summer steelhead (Busby et al. 1996), yet their run timings are clearly discrete. Because of overlaps in spawning migration and timing, differentiating between winter, fall, and summer steelhead can be difficult (Table 1). The KMP steelhead life history variant referred to as 'half-pounder' is comprised of subadults that spend 2-4 months in the Klamath estuary or nearshore marine habitats, overwinter in the lower and middle Klamath River, and return to the ocean the following spring. Half-pounders are most common downstream of Seiad Valley (Kesner and Barnhardt 1972). Winter, fall and summer steelhead are all known to exhibit a half-pounder strategy. A total of 33 different steelhead life history categories at maturity were identified by Hodge (2010) in the Klamath Basin, including non-anadromous and anadromous forms.

Steelhead race	KRSIC (1993)	Hopelain (1998)	USFWS (1979)	Busby et al (1996)	Moyle (2002)
Spring/Summer	May- July	March-June	April-June		April- June
Fall	August- October	July-October	August-November		
Winter	November- February	November-March	November-February		November-April
Stream-maturing				April- October	
Ocean-maturing				September-March	

Table 1. Klamath Mountains Province steelhead run timing.

The following is a description of the three principal steelhead runs recognized in the KMP, as well as a description of half-pounder and early life history stages of all runs.

KMP winter steelhead: Klamath Mountain Province winter steelhead become reproductively mature in the ocean. Winter steelhead typically enter fresh water from potentially as early as September (though more typically November) to March, as mature adults, spawning shortly after migrating to suitable spawning areas (Busby et al. 1996). Spawning peaks before March. Population data are sparse for winter steelhead due to their run-timing, which is concurrent with higher winter flows and turbidity levels. As such, monitoring this run using traditional weirs or spawner surveys is not feasible.

KMP fall steelhead: Klamath Mountain Province fall steelhead enter the Klamath Basin between July and November (USFWS 1979, Hopelain 1998). Fall steelhead migrate into the Klamath and Trinity rivers between August and November and spawn in the mainstem and tributaries during the months of January through May. The fall steelhead run is more abundant than the summer steelhead run and, based upon mark-recapture data (Sinnen et al. 2009), is the main run of fish utilized for hatchery production at Trinity River Hatchery. However, based on trapping data from Willow Creek (Trinity) and the Klamath, a substantial number of non-marked (wild) fish enter the system at the same time as hatchery fall-run steelhead, supporting the separation of fall from summer steelhead in the KMP (W. Sinnen, CDFW, pers. comm. 2014). Nonetheless, fall steelhead are similar to summer steelhead in their level of sexual maturation and spawn timing and probably represents a continuum of the stream-maturing ecotype that encompasses both summer and fall steelhead, perhaps as a result of hatchery practices.

KMP summer steelhead: Summer steelhead in California typically enter rivers during spring months (April-June), while still sexually immature. They then mature in-river over the course of several months (Shapovalov and Taft 1954, Busby et al. 1996, Moyle 2002). Summer steelhead spawn in upstream reaches that are typically not utilized by fall or winter steelhead (Roelofs 1983), including smaller tributary/headwater streams. In the Rogue River, Oregon, spawning begins in late December and peaks in January (Roelofs 1983) and this early spawn timing is apparently also found throughout the KMP. However, in the Trinity River, while summer steelhead are found in tributaries by June, they only appear in the mainstem Trinity above Lewiston by August. In the Klamath River, summer steelhead presumably ascend into summer holding areas by June. Holding areas are typically deep, bedrock pools in remote stream reaches, with subsurface flow or great enough depth to allow for thermal stratification, keeping temperatures cool during low flow periods. Steelhead also utilize thermal refuge plumes emanating from tributary mouths as holding areas in the mainstem Klamath River. While many KMP summer steelhead die after spawning, about 40-64 percent are repeat spawners (Hopelain 1998). Based on their occupancy of headwater streams with relatively low (< 50 CFS) winter flows (Roelofs 1983), fry are assumed to move out of smaller natal streams into larger tributaries soon after emerging.

KMP half-pounder: Half-pounders are small, generally sexually immature, fish (25-35 cm FL), that return to the river in late summer and early fall (between late August and early October); the majority are subadults who have spent only 2-4 months in the Klamath estuary or near-shore environments before returning to the river to overwinter and forage in the lower and mid-Klamath river reaches (Kesner and Barnhart 1972). Recent information suggests that a small proportion (8%) of half-pounders may attain sexual maturity (Hodge 2010). Half-pounder run timing in the Rogue River is generally about a month earlier than in the Klamath (ODFW seine numbers peak in early to mid-August). They return to the ocean the following spring. The presence of half-pounders is uncommon above Seiad Valley in the Klamath River (Hopelain 1998), as are summer steelhead in tributaries above this location. While half-pounders do not typically mature or reproduce in fresh water, they are often encountered during snorkel surveys for adult summer steelhead (and spring Chinook) in the Salmon (Klamath), New (Trinity), and South Fork Trinity rivers (J. Israel, R.Quiñones, and J. Weaver, pers. obs.). However, the presence of over-summering half-pounders with adult summer steelhead is not typically discussed in the literature (Kesner and Barnhardt 1972, Hopelain 1998). Because it is difficult to distinguish between half-pounders and large stream-resident *O. mykiss,* half-pounders are typically not included during snorkel surveys for adult summer steelhead

(E. Wiseman, USFS, pers. comm. 2012). The presence of higher numbers of half-pounders appears to decrease the size of adults at first-spawn. Lower Klamath winter steelhead had the lowest occurrence of half-pounders and the greatest first-year growth rate (Hopelain 1998).

Early life stages: Fry emerge in the Trinity River beginning in April and migrate downstream from May through July (Moffett and Smith 1950). Fry initially move into shallow habitats along stream margins (Moyle 2002) but later establish territories, through aggressive behaviors, in or below riffles (Shapovalov and Taft 1954). In the Trinity River, fry were most common in tributary streams but moved downstream in the early summer, prior to their first winter (Moffett and Smith 1950). Further downstream movement occurred in late fall and winter during periods of higher flows and lower water temperatures. Parr moved the most near the end of their first year and spent their second year in the mainstem. In the Klamath River, relatively equal portions of young-of-year (34%), age-1+ (37%) and age-2+ (27%) steelhead were captured emigrating downstream by rotary screw traps near Orleans from 1997-2000 (USFWS 2001). Most (86%) steelhead returning to the Klamath River apparently spend two years in fresh water before migrating to the ocean (Hopelain 1998). However, steelhead rearing in fresh water for longer periods had shorter downstream migrations (Kesner and Barnhart 1972). Klamath mountain province steelhead live one to three years in the ocean before beginning upstream spawning migrations. Migration patterns in the ocean are unknown.

Habitat Requirements: Steelhead require distinct habitats for each stage of life. The abundance of steelhead in a particular location is influenced by the quantity and quality of suitable habitat, food availability, and interactions with other species. In general, suitable habitats for steelhead are often found farther inland and in smaller streams than those utilized by Chinook and coho salmon (Moyle 2002). Adult steelhead require high flows, with depths of at least 18 cm for passage (Bjornn and Reiser 1991). Reiser and Peacock (1985, in Spence et al. 1996) reported the maximum leaping ability of adult steelhead to be 3.4 m. Temperatures of 23-24°C can be lethal for adults (see Table 2) (Moyle 2002). Steelhead require loose gravels at pool tail-outs for optimal conditions for redd construction and spawning success. Redds are usually built in water depths of 0.1 to 1.5 m, where velocities are between 0.2 and 1.6 m/sec. Steelhead use a smaller substrate size than most other coastal California salmonids (0.6 to 12.7 cm diameter). Steelhead embryos incubate for 18 to 80 days, depending on water temperatures, which are optimal in the range of 5 to 13° C. Hatchery steelhead take 30 days to hatch at 11°C (McEwan and Jackson 1996) and emergence occurs after two to six weeks (Moyle 2002, McEwan and Jackson 1996). High levels of sedimentation (> 5% sand and silt) can reduce redd survival and emergence due to decreased permeability of the substrate and reduced dissolved oxygen concentrations available for incubating eggs (McEwan and Jackson 1996). When fine sediments (< 2.0 mm) compose > 26% of the total volume of substrate, poor embryo survival is observed (Barnhart 1986). Once out of the gravel, emerging fry can survive at a greater range of temperatures than embryos, but have difficulty obtaining oxygen from the water at temperatures above 21°C (McEwan and Jackson 1996).

During the first couple years of freshwater residence, steelhead fry and parr require cool, clear, fast-flowing water (Moyle 2002). Exposure to higher temperatures increases the bioenergetic costs for steelhead and can lead to reduced growth and increased mortality (Table 2). As temperatures become stressful, juvenile steelhead will move into faster riffles to feed, due to increased prey abundance, and seek out cool-water refuges associated with tributary confluences and gravel seeps. Optimal temperatures for growth are estimated to be around 10-17°C (Table 2). However, juvenile steelhead can live in streams that regularly exceed 24°C for a few hours each day if food is plentiful (Moyle 2002).

	Sub-Optimal	Optimal	Sub-Optimal	Lethal	Notes
Adult Migration	<10ºC	10-20°C	20-23°C	>23-24°C	Migration usually stops when temperatures climb above 21ºC, Lethal temperature under most conditions is 22- 24ºC. Fish observed moving at higher temperatures are stressed and searching for cooler refuges.
Adult Holding	<10ºC	10-15°C	16-25°C	>26-27°C	These temperatures are for summer steelhead, which survive the highest holding temperatures. If high temperatures are frequent, egg viability of females may be reduced.
Adult Spawning	<4ºC	4-11°C	12-19°C	>19°C	Egg viability in females may be reduced at higher temperatures.
Egg Incubation	<4ºC	5-11°C	12-17°C	>17°C	This is the most temperature-sensitive phase of life cycle.
Juvenile Rearing	<10ºC	10-17°C	18-26°C	>26°C	Past exposure (acclimation temperatures) has a large effect on thermal tolerance. Fish with high acclimation temperatures may survive 27ºC for short periods of time. Optimal conditions occur under fluctuating temperatures, with cooler temperatures at night. Heat-shock proteins (a sign of stress) start being produced at 17°C.
Smolt-ification	<7ºC	7-15°C	15-24°C	>24°C	Smolts may survive and grow at suboptimal temperatures but have a harder time avoiding predators.

Table 2. Temperature requirements of steelhead, from Richter and Kolmes (2005), McEwan and Jackson (1996), and Moyle (2002). Values may vary according to acclimation history of individuals and strain of trout.

Steelhead have a body form adapted for holding in fast water, more so than most other salmonids with which they co-occur. Hawkins and Quinn (1996) found that the critical swimming velocity for juvenile steelhead was 7.7 body lengths/sec, compared to 5.6-6.7 body lengths/sec. for juvenile cutthroat trout. Adult steelhead swimming ability is hindered at water velocities above 3.0-3.9 m/sec (Reiser and Bjornn 1979, in Spence et al. 1996). Preferred holding velocities are much slower and range from 0.19 m/sec for juveniles to 0.28 m/sec for adults (Moyle and Baltz 1985). Physical structures such as boulders, large woody debris and undercut banks are important habitat components that create hydraulic heterogeneity, increase cover from predators, provide visual separation of juvenile territories, and afford refuges during high flows.

Because upstream migration often coincides with high flows, winter steelhead are able to move into smaller tributaries inaccessible to other salmonids during low flows. Inhabited streams may include those in medium-sized watersheds with confluences that are not passable in the summer/fall seasons due to high rates of sedimentation and associated subsurface flows. They can also migrate into the headwaters of low-order streams, where flows would otherwise be too low to be accessible by large fish.

Over-summering habitat for adult summer steelhead includes pools of moderate size (200-1,000 m^2), with minimum depths of 1.0 to 1.4 m. Although localized areas of cool water (0.2 to 3.8°C lower than the mean hourly pool temperature of 18.0°C) were observed in some pools, Nakamoto (1994) did not find a significant positive relationship between adult fish density and mean hourly pool temperature in the New River. Habitat use was more often associated with physical habitat characteristics such as pool size, substrate embeddedness (<35%), shade from riparian vegetation, and instream cover (Nakamoto 1994, Baigun 2003). Most (99%) of summer steelhead observed in the New River used cover during the day; bedrock ledges and boulders were used more frequently than depth (>1m) or shade (Nakamoto 1994).

Fall steelhead, which migrate during periods of decreasing stream temperatures, are less reliant on deep pools for holding and tend to hold in the mainstem for extended periods of time. It is assumed that these fish enter tributaries after the first series of rainfall-driven freshets in the fall. Fall steelhead trapped and tagged in the lower Trinity River from September through November often do not appear at Trinity River Hatchery until January through March.

Spatial segregation of spawning habitats between winter and summer steelhead reproductively isolates the two runs, facilitating low levels of genetic differentiation (Barnhart 1986, Papa et al. 2007). Summer steelhead often spawn in the upper portions of watersheds in isolated and/or intermittent streams; juveniles move into perennial streams soon after emergence (Everest 1973). In the Rogue River, Oregon, summer steelhead spawn in small headwater streams with relatively low (<50 CFS) winter flows (Roelofs 1983). Roelofs (1983) suggested that use of small streams for spawning may reduce egg and juvenile mortality because, in small stream habitats, embryos are less susceptible to scouring by high flows and juveniles are less vulnerable to predation by adults, due to lower adult densities in smaller streams. Water velocities and depths measured at redds were 23-155 cm sec^{-1} and 10-150 cm, respectively, and diameters of the gravels were typically 0.64-13 cm. The concept of spawning spatial segregation is based largely on summer steelhead distribution and habitat utilization, since little is known about the spawning distribution of fall and winter steelhead throughout the KMP.

Distribution: Klamath Mountain Province steelhead are found in the Klamath River basin and streams north to the Elk River, Oregon, including the Smith (California) and Rogue (Oregon) rivers. In the Klamath River, the upstream limit of steelhead migration is Iron Gate Dam. Historic range likely included tributaries to Upper Klamath Lake, prior to dam construction (Hamilton et al. 2005). In the Trinity River, upstream migration is blocked by Lewiston Dam (Moffett and Smith 1950).

It is likely that the steelhead runs that migrated into the upper Klamath Basin before construction of Copco Dam were KMP summer steelhead. Recent genetic analysis concluded that anadromous steelhead (coastal group) were genetically distinct from redband trout (*O. mykiss newberri*; inland group), which currently persist in the upper basin (Pearse et al. 2011).

Trends in Abundance: Few data are available to evaluate trends in abundance. Adult spawners in the Smith River during the 1960s were estimated at 30,000; recent estimates for the 2010 and 2011 seasons were 16,000 and 15,000 respectively (Larson 2013). Rough estimates for annual size of all steelhead runs combined in the Klamath basin in the 1960s were between 283,000 (CDFG 1965) and 222,000 (Busby et al. 1994). Estimates declined to 87,000-181,000 from 1977 to 1983 (Hopelain 2001), with the winter steelhead run declining to 10,000-30,000 in the main stem Klamath River. Fall steelhead adult runs in the Trinity River were estimated between 7,833 and 37,276 during the 1980s. Returns to Iron Gate Hatchery are highly variable but appear to be in decline (Figure 1; Quiñones et al. 2013). Returns to Trinity River Hatchery, in contrast, appear to be increasing (Figure 1). See below for information related to trends in winter, fall and summer KMP steelhead.

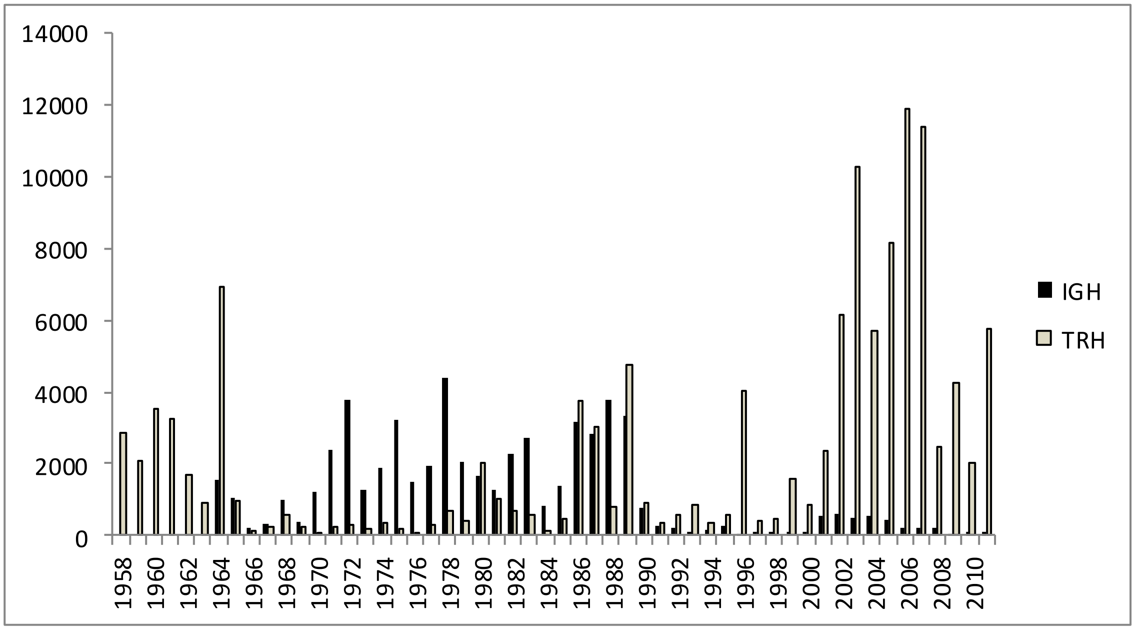

Figure 1. Fall steelhead returns to Iron Gate and Trinity River hatcheries, Klamath River basin, 1958-2011 (Iron Gate and Trinity River hatcheries, unpublished data).

KMP winter steelhead: Data are particularly sparse for KMP winter steelhead, due to the difficulties (high flows, turbidity, surveyor safety concerns) associated with monitoring during the winter months. Recently, DIDSON sonar counts were used to estimate the abundance of winter steelhead in the Smith River (Larson 2013). Estimated winter steelhead abundance for the 2010-11 and 2011-12 seasons was 16,000 and 15,000, respectively. Winter steelhead are the predominate run in the Smith River. There are no long-term (or even recent) estimates for the Klamath Basin for winter steelhead abundance.

KMP fall steelhead: Fall steelhead in the KMP are largely a stream-maturing run and have been classified as summer steelhead by NMFS (Busby et al. 1994, Busby et al. 1996), adding to the confusion related to identifying and managing discrete KMP steelhead runs; however, data from the Trinity River (Sinnen et al. 2009) suggest the fall steelhead run peaks in the lower mainstem Trinity River between September and November. This spawning peak occurs considerably later than summer steelhead counts in tributaries (which occur in August), suggesting that there is a discrete fall steelhead run. Adult steelhead numbers for the fall migration period have been generated for a number of years on the Trinity River and indicate stable, albeit heavily hatchery-supported, runs (Table 3). The run has averaged 15,182 fish/year for the years for which data are available. The wild component has ranged from 1,349 fish to 16,645 fish, averaging 5,579 fish. The hatchery component of this run has ranged between 1,315 and 46,379 fish, averaging 12,350 fish. Populations of fall steelhead, based on run-timing, also exist in upper Klamath tributaries. CDFW counts at two video weirs on the Shasta (CDFW 2013) and Scott rivers (CDFG 2012a) for the 2011-12 season indicate bimodal peaks of migration that occur in mid-October and late December/early January. Steelhead were observed at both weirs throughout September through early January, after which the weirs were removed due to high flows. A total of 251 adult steelhead were observed in the Scott River (CDFG 2012a) and 180 in the Shasta (CDFW 2013) during the operational time frame.

KMP summer steelhead: Little is known about the historical abundance of summer steelhead in the KMP; quantitative records of summer steelhead numbers exist only for recent decades (Roelofs 1983). Given the limited amount of habitat now available since large portions of the upper Klamath and Trinity basins were blocked by dams, it is likely that summer steelhead in the Klamath Basin currently represent only a small fraction of their original numbers. Some summer steelhead populations (e.g., Salmon River) have declined precipitously in the past 30-40 years (Quiñones et al. 2013), while others have shown increases in recent years (e.g., New and North Fork Trinity rivers; E. Wiseman, USFS, pers. comm. 2013). Snorkeling counts for summer steelhead are prone to difficulties such as counting half-pounders as adult steelhead, incomplete spatial surveys, observational biases by surveyors, and low water clarity from rainfall events, and sediment inputs, especially from suction dredging (at least in the past, given the current moratorium on dredging in California). Therefore, survey numbers likely represent the minimum fish present. The majority of estimates for California populations have been less than 100 fish at each location for the past decade, with a few exceptions. In 1989-1991, the three-year average exceeded 500 fish in the North Fork Trinity River and New River, which also had more than 500 fish in 1999-2001 and 2002-2004. These two tributaries averaged more than 800 fish in 2009-2012. Three year averages also exceeded 500 fish for some years in Dillon Creek (2000-2004) and Clear Creek (2001-2003) (T. Jackson, CDFW, pers. comm. 2011). Out of 20 summer steelhead populations surveyed in the Klamath-Trinity basins, eleven averaged <100 fish annually and nine averaged < 20 fish each for the years they were surveyed (Table 4). Average counts for the combined 20 populations for the years 1981 through 1985 were 1,919 fish. The more recent period, 1996 through 2012, averaged 2,923 annually. It appears the larger tributary populations within the KMP, excluding the Salmon River, have stabilized or increased and smaller tributaries continue to support considerably smaller summer steelhead populations. Because effective (breeding) population sizes are likely less than actual counts, many populations may be close to or below the minimum size needed for long-term persistence (Lindley et al. 2007). These abundance estimates are generated from adult fish observed in midsummer (July and August), so mortality prior to the winter spawning period is not accounted for. Most populations were severely affected by the extraordinary floods of 1964, which dramatically altered most KMP stream and river habitats. Although habitats are gradually recovering over time, the abundance of summer steelhead has fluctuated widely in recent years. The status of each major population or subpopulation of KMP summer steelhead is as follows:

Mainstem Trinity River. Moffett and Smith (1950) indicated that summer steelhead were common in the upper mainstem Trinity River in the 1940s. Utilization of this portion of the river persisted through the early 1960s (CDFG 1992), with individuals still present at Junction City (W. Sinnen, CDFW, pers. comm. 2011). Suitable water temperatures downstream of Lewiston Dam provide habitat for summer steelhead; however their current abundance in this section is unknown. It is likely that a large proportion of fish observed in the upper mainstem Trinity River originate from the Trinity River Hatchery.

North Fork Trinity River. There is little historical information on summer steelhead utilization and abundance in this stream, but relatively recent data (1979-2005) indicate that the population fluctuates between 200 and more than 1,200 fish per year (T. Jackson, CDFW, pers. comm. 2011). Summer steelhead distribution has changed relatively little during recent decades of monitoring and the majority of holding habitat occurs in the middle reaches. Their distribution in upper portions of the watershed appears to depend on sufficient flows, while high temperatures may limit their use of reaches closest to the mainstem Trinity River confluence (Everest 1997). Given that this stream has been heavily altered by mining, it is likely that runs were much more abundant in the past (Roelofs 1983). Canyon Creek, a tributary close to the North Fork Trinity River, continues to support very small numbers of summer steelhead and the average count for 24 of 30 years was 19 fish (Table 4).

South Fork Trinity River. There is no historical information on summer steelhead in this stream. Recent counts were as low as 11 fish in 1996; however, in 2006 and 2007, more than 200 fish were observed and, in 2011 and 2012, more than 300 fish were observed. Surveys performed in 2002 indicated that summer steelhead adults were less common than half-pounders, although with a similar distribution (Garrison 2002). All South Fork Trinity River counts of adult summer steelhead are combined with half-pounder steelhead and, in some years, the number of half pounders is substantial.

New River. This tributary to the Trinity River supports the second largest population of summer steelhead in California (T. Jackson, CDFW, pers. comm. 2011). The estimated average abundance for 1979-2006 was 647 summer steelhead. The estimated abundance reached a high of 2,108 fish in 2003, averaged 977 between 2004-2006, and, most recently, averaged 903 between 2007 and 2012.

Klamath River tributaries. Since 1985, summer steelhead counts were generally less than 100 fish in six tributaries: Bluff, Red Cap, Camp, Indian, Thompson, and Grider creeks (J. Grunbaum, pers. comm. 2010). The summer steelhead populations in Elk Creek averaged about 110 fish during this same period. Dillon and Clear creeks have the largest summer steelhead populations on the Klamath River, averaging more than 300 fish annually during the years they were surveyed. While there is no clear trend among the smaller populations, summer steelhead populations in Dillon and Clear creeks were estimated to be over 1,000 fish in 2002 (Table 4). These estimates have decreased over the past few years and the 2005-2009 average was 207 and 139, respectively.

Salmon River. Adult summer steelhead counts in the Salmon River (North Fork, South Fork, mainstem) were usually less than 150 fish per year each (Klamath National Forest, unpublished data 1990-2011). These watersheds were heavily mined during the late 19th century and smaller scale mining continues in the river during summer. Adult escapement decreased significantly from 1968 to 2009 ($p = 0.00074$; Quiñones et al. 2013). Within the general decreasing trend, adult escapement increased in 1973 and decreased in both 1980 and 1990. Favorable ocean conditions may explain increases in steelhead abundances during the early 1970s, years during cold PDO phases (Mantua and Hare 2002). Likewise, decreases in numbers may reflect unfavorable ocean conditions (warm PDO phase) in the mid- to late-1980s and early 1990s. However, correlation trend data between IGH hatchery steelhead and Salmon River summer steelhead suggest that hatchery stocks are influencing adult escapement trends (Quiñones et al. 2013). Further investigation is needed to explore adult escapement and population trends between hatchery and wild steelhead.

Wooley Creek. As with the Salmon River, to which Wooley Creek is tributary, this stream has maintained a summer steelhead population that is estimated to be between 100-300 fish per year. However, this population declined to an average of 50 individuals annually between 1990 and 2000. Counts increased to 288 fish in both 2003 and 2004, although counts in recent years are similar to those in the 1990s.

Smith River. Only 10-20 fish are estimated to occur annually in each of five tributaries since surveys began in 1978 (T. Jackson, CDFW, pers. comm. 2011); however, the Smith River watershed may never have supported summer steelhead in large numbers (Roelofs 1983), so these small numbers may not reflect actual declines.

Overall, KMP summer steelhead numbers in recent decades appear to have ranged between 1,400 and 4,000 fish in the entire KMP system per year. These estimates almost certainly represent only a small fraction of historic numbers, based on the fact that large areas of formerly accessible habitats are now blocked above dams, that summer steelhead generally utilize these same types of habitats (e.g., smaller tributary headwater streams), and human land and water uses have altered many remaining accessible habitats. Increases in numbers have been documented in some tributaries in recent years, presumably due to a combination of good ocean conditions, recovering stream habitats and restrictive sport fishing regulations.

Table 3. Fall-run adult steelhead (>41cm FL) run-size, spawner escapement, and angler harvest estimates for the Trinity River upstream of Willow Creek weir, 1977 - 2012.

	Run-size estimate					Spawner escapement						Angler harvest		
						Natural Area Spawners[a]			Trinity River Hatchery					
	Hatchery[b]		Wild[c]			Hatchery	Wild	Total	Hatchery	Wild	Total	Hatchery	Wild	Total
Year	Number	Percent	Number	Percent	Total									
1977	No estimates					No estimates			269	16	285	No estimates		
1978	"					"			628	55	683	"		
1979	"					"			329	53	382	"		
1980	8,449	33.7	16,645	66.3	25,094	5,101	14,462	19,563	1,903	102	2,005	1,445	2,081	3,526
1981	No estimates					No estimates			892	112	1,004	No estimates		
1982	2,106	20.0	8,426	80.0	10,532	971	6,889	7,860	634	79	713	501	1,458	1,959
1983	No estimates for hatchery/wild component				8,605			6,661			599			1,345
1984	"				7,833			6,430			142			1,261
1985	No estimates					No estimates					461	No estimates		
1986	"					"					3,780	"		
1987	"					"					3,007	"		
1988	No estimates for hatchery/wild component				12,743			11,926 [d]			817	"		
1989	"				37,276			28,933			4,765			3,578
1990	"				5,348			3,188			930			1,230
1991	"				11,417			8,631			446			2,340
1992	1,315	43.2	1,731	56.8	3,046	759	1,540	2,299	430	25	455	126	166	292
1993	1,894	58.4	1,349	41.6	3,243	801	1,176	1,977	875	10	885	218	163	381
1994	1,477	34.8	2,767	65.2	4,244	878	2,410	3,288	403	8	411	196	349	545
1995	1,595	37.2	2,693	62.8	4,288	1,424	1,867	3,291	24	681	705	147	145	292
1996	8,598	82.4	1,837	17.6	10,435	4,127	1,703	5,830	3,964	48	4,012	507	86	593
1997	No estimates for hatchery/wild component				5,212	No estimates		4,267	No estimates		429	No estimates		516
1998	"				2,972	"		2,463	"		441	"		68 [e]
1999	"				5,470	"		3,817	"		1,571	"		82 [e]
2000	"				8,042	"		7,097	"		768	"		177 [e]
2001	"				12,638	"		9,938	"		2,333	"		367 [e]
2002	14,408	75.6	4,650	24.4	19,058	7,730	4,566	12,296	5,966	42	6,008	697	57	754 [e]
2003	19,245	83.0	3,947	17.0	23,192	8,717	3,837	12,554	10,182	42	10,224	346	68	414 [e]
2004	15,038	75.7	4,817	24.3	19,855	8,937	4,732	13,669	5,688	37	5,725	413	48	461 [e]
2005	14,049	72.4	5,363	27.6	19,412	5,782	5,280	11,062	8,080	63	8,143	187	20	207 [e]
2006	32,609	78.8	8,781	21.2	41,390	20,272	8,660	28,932	11,509	38	11,547	828	83	911 [e]
2007	46,379	86	7,506	14	53,885	31,923	7,405	39,328	11,366	31	11,397	3,090	70	3,160 [e]
2008	9,538	64	5,477	36	15,015	6,680	5,415	12,095	2,471	24	2,495	386	38	424 [e]
2009	13,314	73	5,047	27	18,361	7,704	4,877	12,581	4,234	17	4,251	1,376	154	1,530 [e]
2010	4,640	55	3,811	45	8,451	2,468	3,749	6,217	2,000	37	2,037	172	25	197 [e]
2011	15,243	68	7,059	32	22,302	8,690	6,977	15,667	5,700	50	5,750	853	33	886 [e]
2012[f]	12,405	59	8,507	41	20,912	6,281	8,385	14,666	5,685	52	5,737	439	70	509 [e]

a/ Natural area spawners includes both wild and hatchery fish that spawn in areas outside Trinity River Hatchery.
b/ Trinity River Hatchery-produced steelhead.
c/ Naturally produced steelhead.
d/ The natural spawner escapement reflects an overestimate due to the unknown number of fish harvested by anglers upstream of Willow Creek Weir.
e/ Harvest was limited to hatchery-produced fish only. Hatchery fish are those with an adipose fin-clip.
f/ Preliminary data only.

Table 4. Observed number of summer steelhead in Klamath Mountain Province stream and rivers. Numbers should be regarded as indicators of relative abundance, rather than population estimates, since survey efforts may have differed by year and location. Some survey results include half pounders.

Watershed	Source	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Bluff	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	41	37
Red Cap	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Camp	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Dillon	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	236
Clear	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	1810	79	241
Elk	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	408	ns	90
Indian	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	421	ns	ns
Thompson	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Salmon mainstem	A,B,C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	65
Wooley	A,B,C	ns	ns	33	ns	20	ns	45	ns	ns	124	ns	510	105	160	165
NF Salmon	A,C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	69
SF Salmon	A,C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	166
Grider	B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Canyon	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	6
NF Trinity	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	200	320	456
SF Trinity	A,B,D	ns	ns	ns	ns	2	ns	ns	ns	1	ns	ns	ns	ns	91	ns
New	A,B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	341	320
NF Smith	A,D	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
MF Smith	A,D	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
SF Smith	A,D	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Watershed	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Bluff	16	87	23	48	23	73	73	91	58	91	212	149	31	15	20
Red Cap	ns	45	12	11	18	ns	29	25	25	7	2	31	8	4	3
Camp	ns	ns	ns	ns	ns	ns	ns	ns	18	ns	1	7	ns	2	2
Dillon	187	295	300	200	162	ns	77	294	38	74	88	ns	161	ns	122
Clear	270	18	257	156	162	428	524	693	934	117	39	100	178	134	175
Elk	47	249	ns	18	ns	ns	ns	69	150	57	44	72	61	110	61
Indian	ns	15	ns	ns	ns	ns	ns	46	154	21	8	271	67	117	39
Thompson	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	4
Salmon mainstem	ns	100	ns	ns	ns	ns	ns	ns	13	15	24	24	16	11	25
Wooley	245	353	78	92	290	ns	280	357	234	73	25	17	49	22	34
NF Salmon	5	41	ns	ns	8	8	4	8	17	12	17	15	20	10	11
SF Salmon	16	225	ns	ns	9	9	14	154	ns	21	26	59	26	22	21
Grider	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Canyon	3	20	3	20	10	ns	0	32	ns	15	3	6	24	45	23
NF Trinity	219	193	160	180	57	ns	300	624	347	554	837	367	605	990	830
SF Trinity	ns	27	ns	8	3	73	ns	26	37	66	8	21	23	22	42
New	236	114	ns	335	ns	ns	ns	500	699	381	748	358	368	427	817
NF Smith	ns	2	ns	ns	ns	ns	ns	12	4	8	0	13	0	0	4
MF Smith	ns	2	ns	ns	ns	ns	ns	21	1	18	11	13	5	2	11
SF Smith	ns	2	ns	ns	ns	ns	ns	12	4	8	13	8	4	5	4

Watershed	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Bluff	15	2	15	5	9	9	35	31	20	10	7	18	11	23	10	11	3
Red Cap	6	1	6	3	0	2	9	23	20	10	6	4	0	2	2	2	4
Camp	1	0	4	0	0	2	4	5	3	13	0	15	0	7	2	1	1
Dillon	91	180	151	209	679	929	1108	576	437	216	448	58	ns	107	119	166	119
Clear	102	85	68	65	186	538	1034	238	268	108	158	129	222	78	97	141	132
Elk	96	33	490	23	77	212	200	55	112	34	37	33	68	56	38	87	37
Indian	ns	42	ns	ns	ns	ns	ns	4	ns	ns	30	87	71	442	51	70	29
Thompson	14	13	ns	ns	ns	ns	ns	46	17	9	13	21	9	36	27	0	3
Salmon mainstem	27	13	23	35	17	81	35	46	56	7	1	19	37	47	60	31	31
Wooley	14	18	14	13	32	74	143	240	75	39	ns	53	ns	26	37	24	58
NF Salmon	9	9	22	13	14	24	19	7	18	6	6	10	25	19	19	121	121
SF Salmon	35	8	17	20	14	21	39	11	34	24	35	29	68	45	37	24	24
Grider	ns	ns	0	ns	ns	ns	29	0	44	3	8	16	2	1	7	0	ns
Canyon	5	26	42	16	27	33	13	40	24	7							
NF Trinity	361	328	149	187	380	977	985	1042	453	443	420	399	ns	827	820	1082	1219
SF Trinity	11	95	57	38	221	131	77	144	114	95	214	409	ns	94	322	322	324
New	307	651	495	538	515	995	1500	2108	1156	843	932	898	222	1088	894	1084	1230
NF Smith	4	ns	ns	ns	ns	ns	ns	ns	ns	ns	0	ns	ns	ns	ns		
MF Smith	11	6	6	0	6	0	ns	1	6	2	14	0	5	10	0		
SF Smith	9	0	ns	0	13	1	ns	2	8	ns	11	9	1	ns	3		

Sources: A=McEwan and Jackson 1995; B=USFS, LeRoy Cyr and Jon Grunbaum, Six Rivers and Klamath National Forest; Eric Wiseman, Shasta/Trinity National Forest; C=USFS, Rebecca Quiñones, Klamath National Forest; D=Friends of the Smith River

Effects of Climate Change: Streams in the Klamath Basin downstream of Iron Gate Dam are projected to be warmer and drier during the summer and fall months, due to reduction in total snowpack and seasonal retention of snow (Hamlet et al. 2005, Stewart et al. 2005). Snow pack water content in the last 50 years has already significantly declined at several monitoring stations in the Klamath Basin (Van Kirk and Naman 2008). Lower flows further exacerbate increasing water temperatures, as river depth is often inversely related to water temperature (Allan and Castillo 2007). Climate change may also alter stream flow patterns by increasing winter runoff as rain rather than snow, likely decreasing spring and summer stream flows, and increasing the occurrence of winter floods and summer droughts (Knox and Scheuring 1991, Field et al. 1999). With increased temperatures causing earlier snowmelt, the timing of peak flows has already changed by 10 to 30 days (Stewart et al. 2005), with peak flows occurring earlier in more recent decades (Cayan et al. 2001). Flows in snowmelt-fed rivers (e.g., Salmon River) in the Klamath Basin usually peak in winter with a second, smaller, peak in spring and then gradually decrease to lowest levels in summer. If changes in flow regimes continue at the current rate, then stream flows in the Klamath River Basin are expected to decrease by 10%-50% in the spring and summer, while the frequency of extreme high and low flows are predicted to increase by 15%-20% (Leung et al. 2004, Kim 2005).

Increases in water temperatures will strongly affect the physiology and behavior of salmonids throughout their life histories. Changes in movement patterns are likely to be the most obvious response of individual salmonids to climate change, particularly as fish are exposed to increases in water temperature and changes in stream flow patterns. Most behavioral responses in salmonids are triggered by temperature thresholds and changes in flow (Groot and Margolis 1991). Because temperature increases will hasten developmental rates, and stream flows are predicted to peak earlier in the year, the migration patterns of Klamath salmonids may, correspondingly, shift to earlier in the year. However, photoperiod (day length) at a given site can also influence the initiation of salmonid migrations; thus, migration initiation and timing may become unsynchronized with temperature (Feder et al. 2010).

Another behavioral response of salmonids to increased temperatures is movement into colder waters as a method of thermoregulation. Salmonids use cold water pockets (thermal refuges) in rivers during juvenile rearing and adult migration when water temperatures exceed 22°C (Nielsen et al. 1994, Ebersole et al. 2003, Strange 2010). In summer, use of thermal refuges may make juveniles less susceptible to disease (Foott et al. 1999). Climate change influences could diminish or eliminate cold water pockets as temperatures increase. The reduction of suitable freshwater habitat is expected to result in a northward and/or higher elevational shift in the range of cold water fishes (Mohseni et al. 2003, Battin et al. 2007). As a result, steelhead in the KMP may experience local extinctions and range contractions, particularly since most higher elevation, headwater streams are inaccessible behind large dams.

Altered flow regimes, due to changes in precipitation patterns, may impair salmonid embryo development and juvenile survival. Extreme high flows can scour redds, flush juveniles into suboptimal habitats before they reach critical size, and desynchronize juvenile outmigration timing with the spring oceanic phytoplankton bloom (Mote et al. 2003). Fine (< 4 mm) sediment introduced by intense storm events and associated runoff can smother redds, preventing oxygen from reaching developing embryos or acting as a physical barrier to fry emergence (Furniss et al. 1991). Decreases in summer and fall flows may increase juvenile mortality through stranding and changes in the timing of peak spring and fall base flows may reduce survival of juveniles migrating from rivers into the ocean (Lawson et al. 2004). Increases in winter flows may decrease adult survival or reproductive success, due to the higher metabolic cost of upstream migration at higher flow stages.

The predicted impacts of climate change may particularly affect KMP summer steelhead adults because of decreased summer and fall base flows, increased summer water temperatures, and increased variability of seasonal flow patterns in the upper watersheds summer steelhead occupy. The cumulative impact of these changes is a likely reduction in suitable habitat available for spawning and over-summering (Moyle et al. 2013).

Nature and Degree of Threats: KMP steelhead stocks are the most abundant in California; however, as with all west coast steelhead DPSs, their abundance appears reduced from historic levels, to varying degrees, depending on the run and/or geographical area. Major factors likely contributing to the decline of KMP steelhead include: 1) dams, 2) diversions, 3) logging, and 4) agriculture.

Dams. Like many rivers in California, the Klamath and Trinity rivers have been dammed. Three dams that directly affect KMP steelhead in the Klamath basin are Iron Gate, Dwinnell, and Lewiston dams. All are part of larger projects and these three dams, alone, have blocked access to large portions of formerly utilized KMP steelhead habitats, especially important spawning and rearing grounds in the middle and upper portions of both systems. However, removal of Iron Gate and other upstream dams under the Klamath Basin Hydroelectric Agreement, and concordant Klamath Basin Restoration Agreement, may open up hundreds of kilometers of potential steelhead habitat in the future.

Iron Gate Dam is the downstream-most dam on the Klamath River and is one of six dams that make up USBR’s Klamath Project, which has altered the main stem by regulating flows, increasing water diversions (Lewis et al. 2004) and degrading water quality (Hamilton et al. 2011). Iron Gate Dam has no fishway and, therefore, completely blocks access to historic upstream spawning and rearing habitats. Dam operations have decreased the variability, magnitude, duration, and timing of flows in the Klamath River. As a result, base flows have decreased and peak flows have been dampened. Peak flow timing has also shifted to at least a month earlier than prior to dam construction (Hamilton et al. 2011). Lower flows are of particular concern in the summer because daytime water temperatures can reach 24-26°C across large portions of the Klamath system, reducing available rearing habitat. Juvenile steelhead likely persist in the main stem because of abundant food resources and the presence of thermal refuges. Nevertheless, warm temperatures can be stressful if they alter movement, feeding, or growth patterns.

Dwinnell Dam has blocked access to > 30 km of habitat in the upper Shasta River, a tributary to the Klamath River, since its construction in 1928. The dam, in combination with multiple diversions, has reduced flows in the lower Shasta River. Dwinnell Dam has also altered the natural hydrograph, eliminating peak flows that could improve habitat conditions for steelhead and other salmonids (Lewis et al. 2004).

Minimum daytime water temperatures in summer below the dam are usually higher than 20°C, peaking above 22-24°C, which can create conditions stressful to steelhead. As a result, the quality and quantity of steelhead habitat in the lower Shasta River has been greatly reduced.

Lewiston Dam has blocked access to >170 km of habitat on the Trinity River since 1963. Along with Trinity Dam, located just upstream, the dam has greatly reduced flows and altered the natural hydrograph of the main stem Trinity River. The quality and quantity of steelhead habitat has been substantially reduced as a result. In an effort to restore main stem habitat, the Trinity River Restoration Program (initiated in 2000 as part of the Trinity River Record of Decision) was implemented with the goal of restoring up to 48% of flows into the Trinity River. Since its implementation, restoration has included augmentation of summer flows, habitat improvements, reconnection between the stream channel and floodplain, and spawning gravel supplementation.

Agriculture. Agriculture, especially for alfalfa irrigation, has affected many KMP streams by altering flows and degrading water quality. Flows in many streams within the KMP steelhead range have been decreased by agricultural diversions and pumping from wells adjacent to streams. In some streams, this may be the biggest factor affecting steelhead abundance. Diversions in the Scott and Shasta rivers, in particular, have major impacts on fishes by decreasing flows and returning "excess" water to rivers (Lewis et al. 2004), thereby reducing the amount of suitable habitat. Return water is typically much warmer than that in the river, after passing through ditches and fields, and is also often polluted with pesticides, herbicides, fertilizers, or animal wastes. Although many diversions in the Scott and Shasta valleys are screened to prevent juvenile salmonid entrainment, the effectiveness of such screening has not been adequately evaluated. Better agricultural practices and appropriate mitigation measures could dramatically improve salmonid production in the Shasta and Scott valleys (Lewis et al. 2004). Large-scale marijuana cultivation on public lands in the KMP (one of the more heavily used areas of the state for illegal cultivation) may be negatively impacting riparian and aquatic habitats through water diversion, increased sediment inputs, fertilizer and herbicide or pesticide inputs and solid waste inputs (trash dumps or abandoned growing supplies), although this issue requires further investigation and is confounded by safety risks and law enforcement involvement, limiting the opportunities to document impacts from this widespread activity.

Grazing. Livestock grazing is common throughout KMP watersheds and, in certain areas, contributes to degradation of aquatic and riparian habitats. Stream bank trampling and removal of riparian vegetation by livestock can cause bank sloughing, stream channel lie-back and head-cutting in meadows, leading to increased sediment loads and higher water temperatures in streams (Spence et al. 1996). Impacts may also include reduction in canopy cover (shading) over stream channels, siltation of pools necessary for juvenile rearing (Moyle 2002), or sedimentation of spawning gravels. In areas grazed by large herds or where grazing occurs for extended periods without allotment rotation or exclusion fencing, fecal matter from livestock can also impair water quality and increase nutrient loading, leading to eutrophication.

Instream mining. Gold dredging has occurred in KMP streams since the mid-19th century. Suction dredging can be an important limiting factor because dredgers often concentrate in preferred steelhead habitats in remote areas, where disturbance of habitats and disruption of fish habitat utilization may be particularly acute. A moratorium on suction dredging was implemented by CDFW in 2011; however, in 2012, a state law was enacted requiring CDFW to develop alternatives to a complete moratorium (new regulations and a proposed fee structure for dredging permits) by 2013. Depending on the outcome of this process, some level of suction dredging may continue to occur in KMP streams, although this activity will likely be more heavily regulated.

Mining. Legacy effects of 19th century hydraulic mining still negatively affect KMP steelhead habitats in many areas. Historic mining was widespread and intensive in this region and, in combination with logging (often to support mining), devastated many watersheds. Legacy effects from historic mining may be difficult to distinguish from contemporary impacts from logging, rural development, and other land uses that require road building, vegetation removal, or other landscape alterations that contribute to destabilization of the steep slopes of the Klamath Province and increased sediment loads in rivers and streams. Evidence of direct impacts from mining, historic and current, is apparent in many watersheds in the region (e.g., extensive tailing piles, active mining claims and associated equipment or refuse piles, cable crossings, etc.), indicating that mining may still affect KMP steelhead habitats, although historic impacts were almost certainly greater than they are today.

Transportation. Most KMP steelhead streams are paralleled or crossed by roads, often in many locations. Unsurfaced and unimproved roads (mining, logging, rural residential access) are abundant in the Klamath and Trinity basins and culverts associated with road crossings block access to habitat in many streams, while runoff of fine sediments and pollutants associated with roads can degrade water and habitat quality.

Logging. Contemporary logging, along with associated roads and widespread legacy effects from extensive historic timber harvest, has increased erosion rates of steep hillsides that are prone to landslides and mass wasting in this region, greatly increasing sediment loads in KMP streams (Lewis et al. 2004). Both private and public forest lands in the Klamath Basin have been heavily logged in the past century. In the Smith River basin and other protected coastal streams in the KMP, current logging practices are well managed but legacy effects from past, unregulated, timber harvest may continue to reduce steelhead production in some areas. Adverse impacts are especially acute in tributaries used by steelhead for spawning and rearing (Borok and Jong 1997, Jong 1997, Ricker 1997). Increased sedimentation in spawning areas results in lower egg survival and fry emergence rates in the Shasta and South Fork Trinity rivers. High sediment loads fill deep pools with gravel, embed spawning gravels in fine materials, and create shallower runs and riffles, negatively affecting all life stages of steelhead. Juvenile production can decrease significantly due to pool infilling, loss of cover, and increased water temperatures (Burns 1972). The potential for further mass wasting in the Trinity and Klamath basins is high, due to ongoing timber harvest operations. Deteriorating legacy road crossings are prone to failure in large storm events and recent forest fires may be further contributing to soil instability.

Fire. Most lower KMP tributaries, as well as the lower main stems of larger rivers, are within the marine fog belt, with cooler temperatures and higher fuel moisture levels that inhibit wildfires; however, inland portions of KMP watersheds are subject to frequent fires (e.g., Forks, Salmon, and Corral complex fires, 2013) that, under predicted climate change scenarios, are likely to increase in frequency and intensity. Fires can increase water temperatures of important holding and rearing headwater streams, cause landslides, increase sediment loading, and remove shading canopy cover, all to the detriment of steelhead.

Recreation. Recreational activities in KMP steelhead streams include: angling, boating, gold panning (and other forms of mining), swimming, hiking, and other outdoor activities. The impacts from recreation upon steelhead, especially at the population level, are likely minimal. Intensive motorized boating (e.g., lower Klamath River) may disrupt movement patterns and, potentially, habitat utilization, but this has not been substantiated.

Harvest. Current fishing regulations prohibit the take of wild steelhead and only hatchery (adipose fin-clipped) steelhead are legal to harvest. The influence of recreational angling on steelhead abundance is not known, but is assumed to be minimal. Tribal net fisheries generally do not target steelhead; however, nets are an indiscriminate method of fishing and may capture both wild and hatchery steelhead, especially larger fish, due to the large net mesh size typically deployed for Chinook salmon. Klamath Mountain Province summer steelhead are particularly susceptible to poaching during summer months. Summer steelhead are unusually vulnerable because they are large and conspicuous, aggregate in pools, and are prevented from exiting holding areas by low stream flows. Roelofs (1983) indicated that the most stable populations of summer steelhead are in the most inaccessible streams on public lands, whereas those that are showing signs of severe decline are in areas that are most easily accessible. Roelofs (1983) also indicated that poaching was a factor affecting populations of summer steelhead in, at least, the North Fork of the Trinity, New River, and some tributaries to the Klamath River, although current levels of poaching, 30 years later, are largely unknown. The impact of marine (commercial and recreational) fisheries on steelhead, in general, is poorly known and adult steelhead are rarely documented as by-catch; however, these activities may account for some level of ocean mortality.

Hatcheries. Iron Gate and Trinity River hatcheries are operated to mitigate for the loss of habitat upstream of Iron Gate and Lewiston dams. Current mitigation production goals are 200,000 and 800,000 steelhead smolts, respectively. Rowdy Creek Hatchery, on the Smith River, is a privately operated enhancement hatchery and produces approximately 100,000 steelhead smolts annually (Rowdy Creek Hatchery Five Year Management Plan: 2011/12 through 2015/16) (CDFG 2012b). These three hatcheries, combined, produce about 1,100,000 smolts annually (Lewis et al. 2004). While use of native (within watershed) broodstock is the current practice, fish from outside the Klamath Basin have also been used for broodstock in the past. Fish were transferred from the Sacramento, Willamette, Mad and Eel rivers prior to 1973 (Busby et al. 1996), with unknown consequences related to the genetics of native stocks. Recent studies, however, suggest that hatchery propagation can deleteriously affect the genetics of wild stocks (Goodman 2005, Araki et al. 2008, Chilcote et al. 2011). Interactions between wild and hatchery steelhead are recognized as needing further evaluation (CDFG 2001). In April, 2012, the California Hatchery Scientific Review Group (HSRG) released the California Hatchery Review Report (California HSRG 2012). The report focused on California anadromous fish hatcheries, including Iron Gate and Trinity River hatcheries. The goal of the HSRG review was to ensure that hatchery programs are managed and

	Rating	Explanation
Major dams	High	Major dams block access to large areas of spawning and rearing habitat, alter temperature regimes, and otherwise modify downstream habitats
Agriculture	Medium	Agriculture and water diversions in the KMP, including those for illegal marijuana cultivation, reduce flows and degrade water quality
Grazing	Medium	Cattle/livestock grazing may have substantial but localized impacts
Rural residential	Low	Rural development is widely dispersed but increasing in the region
Urbanization	Low	Minimal urban development within the KMP
Instream mining	Low	Suction dredging has been common throughout KMP watersheds and legacy effects of past gold mining still exist in many areas
Mining	Low	Impacts from hardrock mines and their effluents, while widespread in the KMP, appear to be low
Transportation	Medium	Most primary streams have roads along almost their entire length; roads along rivers degrade water quality and simplify stream habitats
Logging	Medium	Logging is pervasive in KMP watersheds and continues to degrade habitats; legacy effects in watersheds without recent logging continue to limit steelhead production
Fire	Medium	Wildfires are common in KMP watersheds and can result in high levels of sedimentation; fire frequency and intensity predicted to increase with climate change
Estuary alteration	Medium	The Klamath River estuary is relatively unaltered; however, the Smith River estuary has lost ~50% of its historic rearing habitat (Quiñones and Mulligan 2005)
Recreation	Low	Habitats used by summer steelhead for holding are particularly sensitive to recreational use
Harvest	Low	The sport fishery in the KMP is well regulated - illegal to take wild steelhead; poaching may be a limiting factor in some areas
Hatcheries	Medium	KMP hatcheries produce ~ one million steelhead a year; interactions between wild and hatchery steelhead may be detrimental and require further study
Alien species	Low	Alien species are uncommon within KMP watersheds with no known impacts to steelhead

Table 5. Major anthropogenic factors limiting, or potentially limiting, viability of populations of KMP steelhead in California. Factors were rated on a five-level ordinal scale where a factor rated “critical” could push a species to extinction in 3 generations or 10 years, whichever is less; a factor rated “high” could push the species to extinction in 10 generations or 50 years whichever is less; a factor rated “medium” is unlikely to drive a species to extinction by itself but contributes to increased extinction risk; a factor rated “low” may reduce populations but extinction unlikely as a result; and a factor rated “no” has no known negative impact to the taxon under consideration. Certainty of these judgments is moderate. See methods section for descriptions of the factors and explanation of the rating protocol.

operated to meet one or both of the primary purposes for hatcheries: 1) aid in the recovery and conservation of naturally spawning salmon and steelhead populations; and, 2) supporting sustainable fisheries while minimizing impacts to natural populations. The report includes recommendations for improving steelhead management and production at both Iron Gate and Trinity River hatcheries.

Status Determination Score = 2.8 - High Concern (see Methods section, Table 2). The original KMP steelhead ESU (now DPS) was first determined to be “not warranted” for listing under the federal ESA by NMFS in March, 1998. A court decision overturned the ruling in 2000, finding that NMFS relied too heavily on expected effects of future conservation efforts. A final decision was reached on April 4, 2001, and the listing of KMP steelhead ESU under the ESA was again determined to be unwarranted. KMP steelhead are listed by the U.S. Forest Service, Pacific Southwest Region, as a Sensitive Species and are managed by CDFW for sport fishing.

Due to the distinctive life history variations (winter, summer, fall, half-pounder, resident forms), diverse watershed characteristics and impairments, and the difficulties in monitoring during periods of high flow/turbidity, abundance estimates for the entire KMP steelhead DPS are not available. Instead, abundance is determined on a smaller scale, focusing on seasonal timing for individual watersheds. Based on seasonal conditions and survey feasibility, summer and fall adult steelhead have the largest data sets. Relatively few data are available for winter steelhead; however, new monitoring technologies (DIDSON) are providing estimates on the Smith River.

Decreases in hatchery abundances are most noticeable in the Klamath Basin, where recent estimates are well below estimates from just two decades ago. Statistically significant decreases in adult returns were detected for steelhead returning to Iron Gate Hatchery ($p = 0.0004$; Quiñones 2011). Most of the steelhead returning to Iron Gate Hatchery are assumed to be fall steelhead, while the abundance of wild winter steelhead in the Klamath Basin is unknown. Hatchery steelhead returns to Iron Gate Hatchery experienced significant changes in 1969 (increase), 1970 (increase), 1989 (decrease), 1990 (increase), 1995 (decrease), and 2000 (increase). Favorable ocean conditions may explain increases of steelhead abundances during the mid-1960s to early 1970s and in 2000, years during cold Pacific Decadal Oscillations (PDO) phases (Mantua and Hare 2002). Likewise, decreases in numbers may reflect unfavorable ocean conditions (warm PDO phase) in the mid- to late-1980s and early 1990s. Continued and proposed restoration efforts (dam removal, improved agricultural practices) could improve the health of Klamath Basin populations. Returns for fall steelhead to the Trinity River Hatchery have fluctuated over the past decade and, although returns are lower than historical records, the population appears stable. The wild population of fall steelhead on the Trinity also appears to be stable. The Smith River watershed is still largely undisturbed and wild steelhead abundance, although reduced from historic estimates, appears to be stable.

KMP summer steelhead have a spotty distribution throughout the KMP and specialized habitat requirements, making each subpopulation more susceptible to environmental changes and anthropogenic threats than adult winter and fall steelhead. Adult abundance for summer steelhead was historically small and continues to be so, but most populations appear to be stable (Table 4). However, specific threats (i.e., fire, sedimentation, climate change, poaching) are more likely to impact subpopulations, leading to local extirpations. Currently, there are no coordinated, basin-wide, management plans in place for the protection of summer steelhead.

Metric	Score	Justification
Area occupied	4	KMP steelhead are found throughout KMP watersheds; adult summer steelhead have the most restricted distribution due to their life history requirements and lack of access to upper watershed portions of historic range
Estimated adult abundance	3	KMP winter steelhead abundance is largely unknown; summer steelhead subpopulations are small and isolated; fall steelhead are the most abundant, although numbers are heavily supplemented by hatcheries
Intervention dependence	2	Continuous management actions needed for habitat restoration/protection, improved water quality/quantity, law enforcement for the sport fishery and poaching
Tolerance	3	Require clear, cool water; adult summer steelhead require cold water refuges
Genetic risk	3	Presumably generically diverse; however, potential hybridization risk with hatchery steelhead
Climate change	3	All KMP watersheds are projected to be negatively affected by climate change; seasonal water temperatures and flows are already marginal in many areas
Anthropogenic threats	2	See Table 5
Average	2.9	20/7
Certainty (1-4)	3	Data are particularly sparse for KMP winter steelhead; summer steelhead are relatively well studied and monitored annually; fall steelhead are well documented, for both wild and hatchery runs

Table 6. Metrics for determining the status of KMP steelhead in California, where 1 is a major negative factor contributing to status, 5 is a factor with no or positive effects on status, and 2-4 are intermediate values. See methods section for further explanation.

Management Recommendations: Restoration and management recommendations for KMP steelhead have been outlined in several plans (Jones et al. 1980, Roelofs 1983, McEwan and Jackson 1996, Voight and Waldvogel 2002). The California Department of Fish and Wildlife, along with partnering agencies/organizations, are dedicated to implementing key elements of these plans to effectively protect and manage KMP steelhead. Objectives include:

1. Increasing naturally-produced stocks of steelhead through the protection of selected subbasins, where natural processes take precedence over human use, in order to create refuges to protect steelhead distribution and diversity.
2. Improving flows below Iron Gate and Lewiston dams. This has already taken place to a certain extent; for example, the Trinity ROD stipulates that ~50% of annual inflow goes to the river whereas, historically, up to 90% was diverted at Lewiston.
3. Restoring favorable instream conditions to benefit multiple species and desired ecosystem functions, rather than focusing on single species management. This concept recognizes that steelhead in the Klamath Basin are a component of a larger community of native fishes, including other salmonids, and restoration efforts should strive to benefit the entire aquatic community.
4. Complete management plans for each subpopulation of summer steelhead throughout the KMP. This task was referenced as “being prepared by DFG” (McEwan and Jackson 1996, p 139), but has not yet been completed.
5. Reduce impacts of hatchery steelhead on wild steelhead populations. Hatchery genetic management plans are being drafted and current hatchery operations are being evaluated based on recent independent scientific review (California HSRG 2012).

Watersheds identified by McEwan and Jackson (1996) as high priority areas for stream restoration to benefit KMP steelhead included: the South Fork of the Trinity River, Scott River, and Shasta River. Many subbasins of the Klamath River are predominantly surrounded by USFS administered public lands and were designated key watersheds as part of the Northwest Forest Plan. Additional measures, such as conservation easements, are required on private lands to restore functioning aquatic habitats and steelhead populations. Fish and watershed monitoring and restoration projects, along with popular sport fisheries, are playing an increasing role in the local economies of the Klamath River Basin, whereas extractive resource industries (timber, mining, etc.) dominated in the past. However, without improved flow management and suitable water quality (i.e. cool and sediment-free), the effectiveness of restoration in many areas will be marginalized (Wu et al. 2000).

In recent years, significant resources have been directed toward mitigating many of the detrimental effects road building and timber harvest have had on KMP steelhead and their habitats (e.g., see http://www.dfg.ca.gov/fish/Administration/Grants/FRGP/). Additionally, private landowners that graze livestock in riparian areas and divert water for agriculture have increased protection efforts such as fencing of riparian areas in the Scott and Shasta valleys. Continued funding for upslope restoration on private lands, fencing riparian areas, and improving water conservation will be necessary at a watershed scale, with greater participation by landowners, in order to benefit KMP steelhead in places like the Shasta and Scott rivers. Removal of migration barriers in tributaries, replanting riparian areas, adding complex woody debris to stream channels, and reducing sediment inputs into rivers and streams are ongoing needs.

More research is needed on the life history diversity of KMP steelhead, especially in the Klamath Basin. Managers would benefit from a better understanding of the physical and biological cues that lead to their wide variety of migration and habitat utilization patterns. Determination of survival and escapement rates for wild steelhead is essential to understanding the viability and persistence of individual subbasin populations. For an accurate assessment of the status, distribution and abundance of all populations, monitoring must expand and be well coordinated within the KMP. Additional information regarding the genetics, ecology, and behavior of KMP steelhead is also needed and will help inform management and conservation strategies.

The highest degree of protection for KMP steelhead (and other fishes) is found in the Smith River (Del Norte County), which is the largest river in California without a major dam. In 1990, the Smith River National Recreation Area Act was signed by President George H. W. Bush as Public Law 101-612, which provides some degree of protection. As in the Klamath Basin, where intergovernmental cooperation among tribes, state, and federal agencies, and non-governmental organizations has played an important role in protecting steelhead habitat, a local conservation group (Smith River Alliance) is actively involved in working with federal and state agencies, local stakeholders, tribal representatives, and others to protect the Smith River and its fish fauna. The conservation strategy of acquiring large tracts of private lands to protect important watersheds, such as Goose, Mill, and Hurdygurdy creeks, is a valuable mechanism for conserving steelhead sanctuaries.

Special management consideration should be afforded to KMP summer steelhead populations. Conservation measures should focus on reducing human impacts and improving habitats, especially in ways that improve minimum base flows and maintain cool water temperatures. Summer steelhead populations would benefit, in particular, from restoration actions that reduce impacts from logging and mining (and the many roads created to facilitate these activities). Summer holding and rearing habitat has been repeatedly identified as a critical limiting factor to summer steelhead populations. Land management strategies that seek to reduce sedimentation, increase cover, and minimize other stressors that negatively affect over-summering habitat for adults are critical to recovering populations.

Summer steelhead management should address: (1) improving enforcement of fishing and land use regulations in over-summering areas, (2) identifying watershed management approaches that minimize sediment delivery to streams and maintain high water quality, (3) improving management and, where necessary, implementing restoration of downstream reaches to favor out-migrating smolts, (4) rebuilding present populations through identifying and affording protection to key refuge streams, and (5) restoring populations that have become extirpated. Strategies should incorporate approaches from the Steelhead Restoration and Management Plan for California (McEwan and Jackson 1996).

There is also a considerable need for research on summer steelhead populations in California, especially to determine: (1) genetic identities of each population, (2) extent of suitable summer holding areas, (3) spatial distribution of spawning areas and whether they require special protection, (4) habitat requirements of out-migrating smolts, and (5) effects of poaching and disturbance from recreation or other human activities on adults. For most populations, there is a need to continue monitoring surveys, as well as identify and mitigate the factors that limit their abundance.

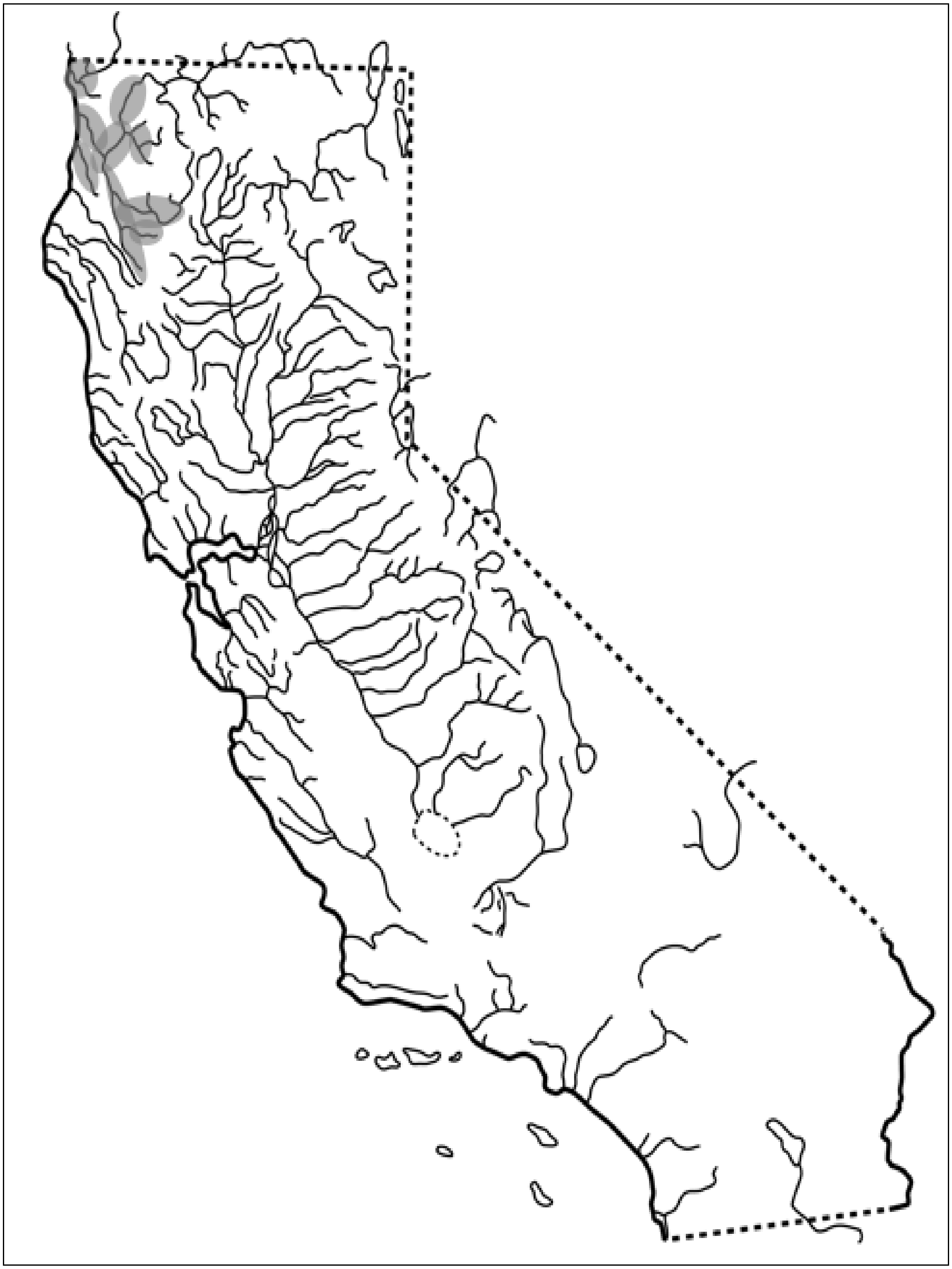

Figure 2. Distribution of Klamath Mountain Province steelhead in California. Individual runs occupy varying portions of the range.